
Association of American Railroads

ADVANCE REPORTS

SECOND ANNUAL MEETING

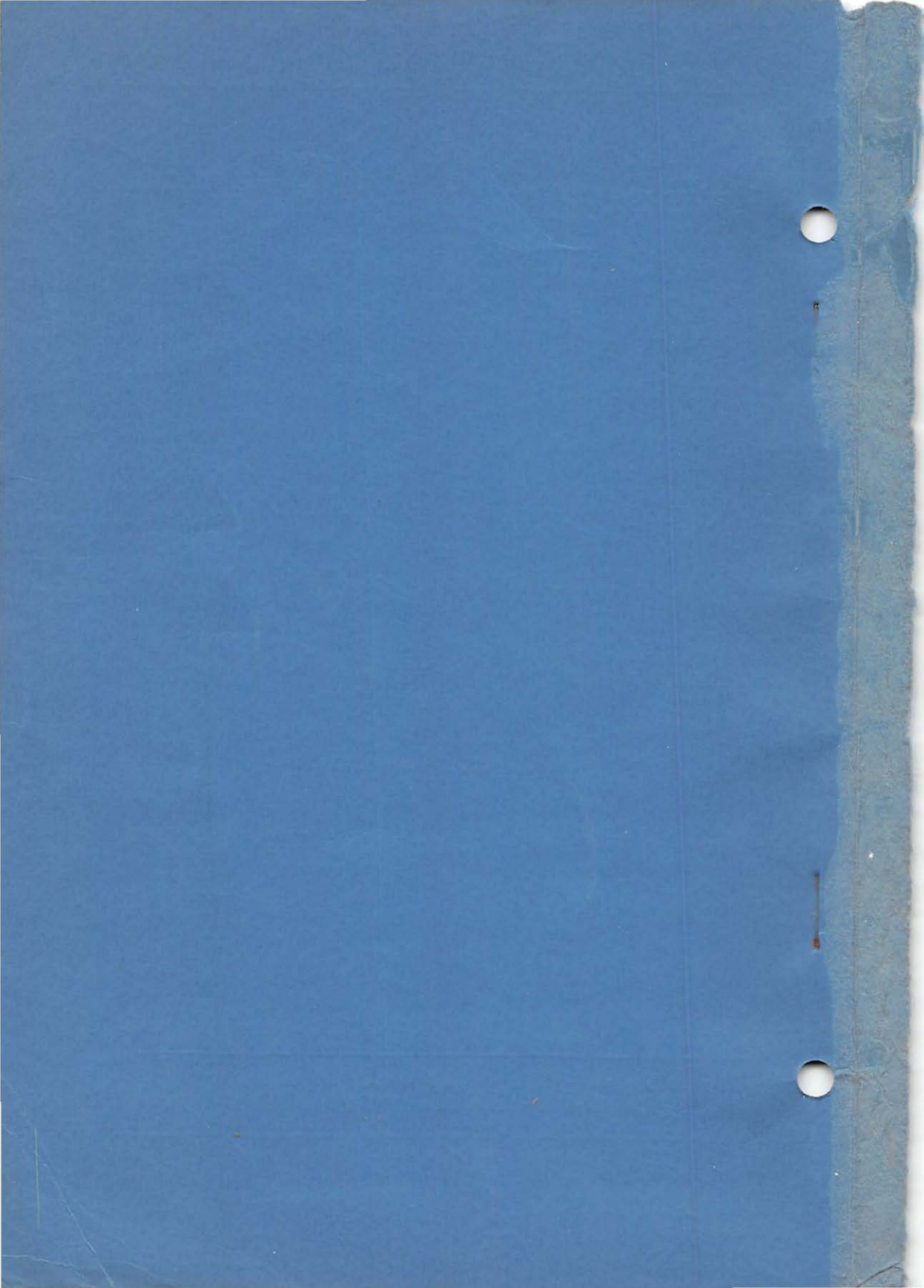
Communication and Signal Section

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Association of American Railroads

OPERATIONS AND MAINTENANCE DEPARTMENT

OPERATING-TRANSPORTATION DIVISION

COMMUNICATION AND SIGNAL SECTION

August 30, 1962

TO THE MEMBERS:

The reports of committees of the Communication and Signal Section contained herein reflect the objectives of the Section to advance knowledge of the principles of engineering, design, construction, operation and maintenance of railroad communication and signal systems. The 1962 Annual Meeting will provide the forum for discussion of these reports and special papers.

A table of Contents appears at the end of the book.

You are urged to consider the reports carefully and be prepared to enter into discussions thereon at the Annual Meeting.

Written criticisms or suggestions are welcome, and proper consideration will be given to them. Should you have any comments to make in connection with any report, please forward them promptly to the Chairman of the committee concerned (**with a copy to the Secretary**), in order to allow ample time before the meeting to review the suggestions and make changes or explanations, as necessary.

General distribution of the Advance Reports will not be made at the Annual Meeting, therefore, please bring your copy with you to the meeting.

S. W. MILLER
Chairman

OPERATIONS AND MAINTENANCE DEPARTMENT

C. D. Buford, Vice-President

OPERATING-TRANSPORTATION DIVISION

J. F. Nash, Vice-Chairman

O. H. Zimmerman, Vice-Chairman.

C. A. Lauby, Executive Vice-Chairman.

COMMUNICATION AND SIGNAL SECTION

Officers

Chairman

S. W. Miller, Superintendent Communications, New York, Chicago and St. Louis Railroad, P. O. Box 6119, Cleveland 1, Ohio.

First Vice-Chairman

H. B. Garrett, Signal Engineer, Southern Pacific Company, Southern Pacific Building, San Francisco 5, Calif.

Second Vice-Chairman

J. H. Wallis, Communications Engineer, Baltimore and Ohio Railroad, Baltimore, Md.

Staff

L. E. Kearney, Engineer Communications and Signals.

P. H. Foley, Assistant Engineer Communications and Signals.

A. H. Grothmann, Secretary.

COMMITTEE OF DIRECTION

MEMBERS

Term Expiring December 31, 1962

- East: S. W. Miller, Superintendent of Communications, New York, Chicago and St. Louis Railroad.
- East: J. H. Wallis, Communications Engineer, Baltimore and Ohio Railroad.
- East: F. Youngwerth, General Superintendent Communications and Signals, Erie-Lackawanna Railroad.
- West: H. C. Stratton, General Signal Engineer, Union Pacific Railroad.
- Canada: R. C. Steele, Engineer of Signals, Canadian Pacific Railway.

Term Expiring December 31, 1963

- East: P. A. Flanagan, Superintendent of Communications, Chesapeake and Ohio Railway System.
- East: L. B. Yarbrough, Engineer Signals and Communications, Wabash Railroad.
- West: H. B. Garrett, Signal Engineer, Southern Pacific Company.
- West: A. J. Hendry, Signal Engineer, Northern Pacific Railway.
- Canada: G. H. Pescud, General Manager, Communication Department, Canadian Pacific Railway.

Term Expiring December 31, 1964

- South: J. R. DePriest, Superintendent Communications and Signals, Seaboard Air Line Railroad.
- West: M. F. Black, Superintendent Communications, Denver & Rio Grande Western Railroad.
- West: L. R. Thomas, Superintendent Communications System, Atchison, Topeka & Santa Fe Railway.

Term Expiring December 31, 1965

- New England: W. W. Hartzell, Engineer Signals and Communications, Boston & Maine Railroad.
- South: P. P. Ash, Superintendent Communications and Signals, Louisville & Nashville Railroad.
- West: V. S. Mitchell, Signal Engineer, Chicago & North Western Railway.

REPORT OF COMMITTEE OF DIRECTION

June 15, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

Your Committee of Direction submits the following reports:

Meetings

Since the 1961 Annual Meeting the committee has met on January 10 and 11, and June 6 and 7, 1962. The committee will meet also on October 22, 1962.

Rules of Order

Consideration was given to changes in these rules. However, in order that they may be in conformity with the Plan of Organization and Rules of Order of the Division, no changes were approved. The Rules are shown on pages 9 to 13, inclusive, of the 1961 Advance Reports.

Rules for Standing Committees

These rules have been revised to bring closer uniformity in the standard paragraphs for sections of the Manuals and clarify instructions on "Investigate and report" assignments. The revised rules are submitted as Exhibit A, page 9. Attention is directed to changes in paragraph B-8; Standard Sections for Use in Requirement Specifications—Communications; section 12 of Standard Sections for Use in Unit Specifications—Signal; and the warranties in both of these standards.

Committee on Nominations

In accordance with Article VIII, Section 1(d) of the Rules of Order, the Committee of Direction has named the following Committee on Nominations:

- B. W. Molis (Chairman), Assistant Chief Engineer, Denver and Rio Grande Western Railroad.
- W. W. Beard, Assistant Signal Engineer, Baltimore and Ohio Railroad.
- P. S. Hughel, Superintendent Communications, New York Central System.
- G. R. Van Eaton, Superintendent Communications, Union Pacific Railroad.
- E. B. Walkup, Signal Engineer, New York, New Haven and Hartford Railroad.

Committees Committee and Special Committees

Committees Committee

- H. B. Garrett (Chairman) Signal Engineer, Southern Pacific Company.
- J. H. Wallis, Communications Engineer, Baltimore and Ohio Railroad.
- H. C. Stratton, General Signal Engineer, Union Pacific Railroad.
- R. C. Steele, Engineer of Signals, Canadian Pacific Railway.
- L. R. Thomas, Superintendent Communications System, Atchison, Topeka and Santa Fe Railway.

Rules for the Committees Committee are shown on page 14 of the 1961 Advance Reports.

Special Committee on Research Assignments

- J. R. DePriest (Chairman), Superintendent Communications and Signals, Seaboard Air Line Railroad.
- M. F. Black, Superintendent Communications, Denver and Rio Grande Western Railroad.
- A. L. Essman, Chief Signal Engineer System, Burlington Lines.
- V. O. Smeltzer, Superintendent Signals System, Atchison, Topeka and Santa Fe Railway.
- R. B. Steele, Regional Manager, Telecommunications Department, Canadian National Railways.

Special Committee on Editing

- A. H. Grothmann (Chairman), Secretary.
 - E. A. Burgin, Superintendent Signals, Chesapeake and Ohio Railway System.
 - P. B. Burley, Superintendent Communications and Electrical Engineer, Illinois Central System.
 - H. C. Macomber, General Superintendent Communications, Missouri Pacific Railroad.
 - V. O. Smeltzer, Superintendent Signals System, Atchison, Topeka and Santa Fe Railway.
 - L. B. Yarbrough, Engineer Signals and Communications, Wabash Railroad.
- Rules for the Editing Committee are shown on page 15 of the 1961 Advance Reports.

Special Committee on Education and Training of Employees

- E. B. Platt (Chairman), Assistant to Signal Engineer, Illinois Central Railroad.
- H. D. Brown, Supervisor Communications, Chicago, Burlington and Quincy Railroad.
- J. V. Knight, Circuit Engineer, Pennsylvania Railroad.
- T. J. Kremer, Supervisor Signals, Illinois Central Railroad.
- J. H. Sawyer, District Signal Engineer, Western District, New York Central Railroad.
- F. W. Zabrockas, Signal Supervisor, Chicago and Western Indiana Railroad.

Special Committee on Railroad-Commercial Communication Liaison**Railroad**

- P. A. Flanagan (Chairman), Superintendent Communications, Chesapeake and Ohio Railway.
- J. M. Hesser, Assistant Superintendent Signals and Communications, Norfolk and Western Railway.
- R. C. Karvatt, Director of Communications, New York Central System.
- D. Ruff, Assistant to Vice President-Communications, Southern Railway System.
- J. H. Wallis, Communications Engineer, Baltimore and Ohio Railroad.

Commercial

- B. F. Campbell, Staff Supervisor-Sales, American Telephone and Telegraph Company.
- R. Maher, Staff Representative-Sales, American Telephone and Telegraph Company.

- W. D. Orr, General Sales Supervisor, Private Wire Services, The Western Union Telegraph Company.
E. L. Parkington, Manager, Engineering Services—Private Wire Services, The Western Union Telegraph Company.
T. R. Warner, Radio Engineer, United States Independent Telephone Association.

Standing Committees

The personnel of standing committees and assignments thereto are listed herein preceding their reports.

The committee appreciates the wholehearted efforts put forth by these committees during the past year and extends its thanks to the chairmen and members. To the retiring chairmen, especial appreciation is tendered with the sincere hope that the retiring chairmen will, as members, continue to give their full support to their committees.

Letter Ballot Approval

Items accepted at the 1961 Annual Meeting for submission to letter ballot for inclusion in the Communication and Signal Manuals were submitted to the Senior Representatives of Member Roads on November 8, 1961 (Circular C&S-15) and approved. The results of the ballot were transmitted to the Senior Representatives on February 15, 1962 (Circular C&S-23). These items comprised the 1961 set of additions and revisions of the respective Manuals.

Publications of the Section

The following publications have been distributed since the last report of the committee:

- 1961 Advance Reports
- 1961 Proceedings
- 1961 Additions and Revisions to Signal Manual
- 1961 Additions and Revisions to Communication Manual

Annual Meetings

The following special papers, talks and panel discussions have been scheduled for the 1962 Annual Meeting:

- The Impact of the Scientific Revolution Upon the Next Fifty Years of Electronic Development, by D. E. Noble, Vice President, Motorola Communications and Electronics Inc.
- Pulse Code Modulation, by Claude S. Davis, Transmission Systems Development Engineer, Bell Telephone Laboratories, Inc.
- Safety, by G. M. Dempsey, Assistant Superintendent Safety, Chicago, Milwaukee, St. Paul & Pacific Railroad.
- Solid State Switching, by Union Switch and Signal Division of Westinghouse Air Brake Co.
- Signal Control Under Disaster Conditions, by H. B. Garrett, Signal Engineer, Southern Pacific Company.
- Talking Hot Box Detector, by J. R. DePriest, Superintendent Communications and Signals, Seaboard Air Line Railroad.
- Radio Repeater System in Cascade Tunnel, by R. A. Johnson, Engineer Signals and Communications, Great Northern Railway.
- Panel Discussion on Hot Boxes.

Panel Discussion on New Concept in Integrated Communications and Its Technical Implications.

The 1963 Annual Meeting will be held at the Sheraton-Chicago on October 9, 10 and 11. The period between October 9 and 16, 1963, has been designated for meetings of AAR and other Railroad groups with combined exhibits scheduled during that time at McCormick Place.

Sectional Meetings

A western sectional meeting was held in Dallas, Texas at the Mariott Motor Hotel on April 24, 1962. Mr. J. H. Laughlin, Signal Supervisor, St. Louis Southwestern Railway, served as Chairman and Mr. C. T. Marak, Signal Engineer, Missouri Pacific Railroad, as Committee of Direction sponsor.

An eastern sectional meeting was held in Cincinnati, Ohio, at the Netherland Hilton Hotel on May 9, 1962, Mr. F. J. Hacker, Supervisor of Communications and Signals, Louisville and Nashville Railroad, serving as Chairman, and Mr. V. P. Shepardson, Assistant Chief Engineer Signals and Communications, Richmond, Fredericksburg and Potomac Railroad, as Committee of Direction sponsor.

Sectional meetings in 1963 are scheduled for St. Louis, Mo., Mr. R. M. Laursen, Superintendent Communications, St. Louis-San Francisco Railway, Chairman, and Mr. L. B. Yarbrough, Engineer Signals and Communications, Wabash Railroad, Committee of Direction sponsor; and for Washington, D. C., Chairman (to be selected), and Mr. J. R. DePriest, Superintendent Communications and Signals, Seaboard Air Line Railroad, Committee of Direction sponsor.

Cooperation with Other Organizations

As indicated in the 1961 report, the list of activities with which the Section collaborates and its representatives thereon has been carefully reviewed and revised. A current list of such activities and representatives is included in Exhibit B, page 35.

Life Members

Since the last annual meeting, death has taken the following life members: E. N. Fox, retired Engineer Signals and Communications, Boston and Maine Railroad.

W. Rogers, retired Superintendent of Telegraph, Missouri Pacific Railroad.

W. S. Storms, retired General Superintendent Communications and Signals, Erie-Lackawanna Railroad.

Affiliated Members

The total number of Affiliated Members is 473.

Railway Affiliated Members

The total number of Railway Affiliated Members is 347.

Many other items of policy and procedure also have been given consideration.

Respectfully submitted,

COMMITTEE OF DIRECTION

Exhibit A

RULES FOR STANDING COMMITTEES

A—Policy

A-1. Each committee will select from its membership a Chairman and Vice Chairman whose term of office shall not exceed two years, or until their successors are selected and qualified. A Chairman or Vice Chairman having served a full term shall not succeed himself.

A-2. To be eligible to serve as chairman of a standing committee, a member should preferably have had three years active committee experience. In general, standing committee chairmen will serve for a maximum term of two years. However, nothing in this rule shall be construed to prevent their appointment at a later date as chairman of another standing committee or reappointment to chairmanship of a standing committee.

A-3. The chairman of each committee is charged with the responsibility for the observance of these rules.

A-4. Meetings of Committees. Meetings of any committee or subcommittee may be held at the request of the chairman thereof, unless for special reasons notified to the contrary by the Chairman of the Section.

A-5. Calls for committee meetings should be issued to all concerned at least two weeks in advance of the meeting and must outline subjects to be discussed at the meeting.

A-6. Calls for full committee meetings shall be issued by the Secretary.

A-7. Only representatives of Member Roads shall have the right to vote in committees and subcommittees.

A-8. The Secretary shall distribute as promptly as possible the minutes of all meetings of committees and subcommittees. The minutes must show the attendance, absent members with reason for non-attendance (if absent member offers no explanation, the minutes will show "no cause given"), and manufacturers or suppliers to whom invitations were extended. If the Secretary is unable to attend a meeting of a committee or subcommittee, the proceedings shall be reported by the chairman and forwarded to the Secretary who will prepare and distribute the minutes.

A-9. Minutes shall be typewritten on standard size sheets with 1½ inch margin on left of sheet for binding.

A-10. Conferees and representatives of the Communication and Signal Section must report to the standing committee designated. Committees must review the reports submitted, and if of interest to the Section, make report at the next Annual Meeting.

A-11. Committee reports concerning highway grade crossing protection and involving changes in aspect or application of devices, as particularly affecting the public, and also reports concerning the subjects of automatic train control and automatic train stop, must, if intended for the Manual, be submitted to the AAR Train Operation, Control and Signals Committee for review before publication in the Manual.

A-12. The Association does not reimburse railroad members for personal or traveling expenses incurred by them in connection with committee work, nor for expenses incident to attendance at Annual Meetings of the Section.

B—Committee Procedure

B-1. To facilitate the work at committee meetings, and in the interest of economy, the work on and discussion of reports and specifications should be carried on as far as practicable by correspondence prior to the meeting.

B-2. Committee chairmen will appoint subcommittees and their chairmen. Where possible, membership should be selected to minimize travel time necessary for attendance at meetings. Railroad members are limited to membership on one subcommittee. The number of subjects assigned to a subcommittee shall not exceed that which can be properly considered.

B-3. Committees or subcommittees may consult with commercial companies, which may or may not be affiliated members, in the preparation of specifications, designs or reports. For this purpose, commercial companies may be invited to send representatives to attend meetings. (See B-10). To obtain economy and efficiency, committees should consult with manufacturers or suppliers before submitting requisites, specifications, instructions, drawings, etc.

B-4. Invitations to manufacturers or suppliers must be addressed to the company, or an officer designated by the company, and must be specific in requesting their attendance when required. They must also be advised of subjects to be discussed, with a brief explanation of points to be considered at that meeting, in order that the company may detail representatives conversant with the particular subjects.

B-5. Correspondence involving manufacturing companies in connection with committee work and invitations to have representatives from those companies (other than Consulting Members) attend committee meetings will be addressed, as advised, by the Secretary.

B-6. In order that committee chairmen may have control over the work of their subcommittees, subcommittee chairmen, unless otherwise directed by the chairman, shall handle all matters with outside organizations or with other committees of the Section or Association through the chairman of the committee of which the subcommittee is a part. (See B-10.)

B-7. In the preparation of reports each committee or subcommittee, with approval of the chairman of the full committee, shall consult with other Divisions and Sections of the AAR, obtaining from them such matter as they have relative to the subject being considered and endeavor to adopt or reconcile what is proposed with what is in existence so as to avoid duplication. The necessary arrangements for such consultation should be made through the Secretary.

B-8. Committees or subcommittees are privileged to report through the usual committee channels as information to the Section such apparatus, material, design and methods as in their opinion would be of vital interest to the Section. The reports must conform to the following requirements:

(a) On investigation and report items specifically assigned to the committee, the report should be confined to information not ordinarily available and in general reflect the experience of railroads with new devices or practices.

(b) They may report the results of any special study or investigation on any of their assigned subjects that they may deem of sufficient importance to warrant presentation. Such report shall include the committee's recommendation as to the application and relation to the assigned subject.

(c) Within the scope of their activities, they may report on such apparatus, material, design and methods used in other industry, which in their opinion would serve an essential need in the communication or signal field. Such report should include the committee's recommendations for modification, if required, and the proposed use of such items covered by the report.

(d) Names of railroads, manufacturers and trade names should not appear in these reports; however, the Secretary must be supplied with this information so it may be available on request. Where there are several manufacturers of an item under investigation, full consideration should be given to all the available items.

B-9. Where there appears to be conflict between the work in progress or previously completed, or in assignments to committees, chairmen shall confer with the Secretary.

B-10. Correspondence and Files. Complete copies of all correspondence between chairmen and members of committees and subcommittees and others relative to committee work or pertaining to the work of the Section shall be forwarded to the Secretary for his information.

B-11. Members of committees and subcommittees who receive copies of a joint letter shall forward copies of their replies to all recipients of such joint letter.

B-12. If committees or subcommittees require data and information from the Section, circulars of inquiry, brief and concise, shall be prepared. The questions asked must be specific and pertinent, and not of such general or involved character as to preclude obtaining prompt and satisfactory responses. They must specify to whom answers are to be sent and must be in such form that copies may be retained by persons replying. Copy of each circular of inquiry desired by committees must be forwarded to the Secretary, who will issue them upon approval of the Chairman of the Committees Committee.

B-13. Research projects recommended for handling by the AAR Research Center must be submitted to the Special Committee on Research Assignments of the Communication and Signal Section for approval and transmittal to the Director of Engineering Research, AAR.

B-14. The retiring chairman of a committee or subcommittee shall transmit to the new chairman the files of such committee or subcommittee so that its work will be continuous.

C—Reports

C-1. Filing Date. The Secretary will advise committee chairmen the deadline date for filing reports to be printed in Advance Reports.

C-2. All subjects to be presented to the Section for letter ballot action must be printed in the Advance Reports. No supplementary reports shall be issued without permission of the Committees Committee.

C-3. Form. Reports of committees shall be prepared in accordance with sample form shown below.

REPORT OF COMMITTEE..... (Number and Name) (Insert personnel of committee,..... giving names, titles and railroads)..... (Date) To the Communication and Signal Section: The following subjects have been assigned to this committee: 1.(Insert assignments to..... committees, arrange..... 2.numerically.)..... The committee submits for consideration, reports on the following subjects: 1.(Show number of assignment being..... reported upon but do not repeat..... 2.assignment. Follow report upon..... each item with action recommended)..... Action Recommended (Use one of the forms in Rule C-9) Respectfully submitted, Committee..... (Number and Name)
--

Sample Form Committee Report

C-4. Subject matter prepared jointly by this Section with other Sections or Divisions of the AAR must be handled as a regular committee report. If such subject matter is adopted by letter ballot, it will be placed in the Manual with a note reading: "Joint specification prepared by....."

C-5. Reports on Assignments. In the preparation of a report, a brief history of the subject matter under discussion, with an outline of its origin and development, may be given.

C-6. If necessary, to make clear the connection between the work of the current and preceding years, the previous report shall be reviewed and action thereon stated. Reference to the Manual and to the proceedings shall be given.

C-7. Committee chairmen shall carefully review their reports and see that they are in the best possible condition before submitting them to the Section.

C-8. Presentation of Reports—Annual Meetings. The method of consideration of committee reports will be one of the following:

- (a) Reading by title.
- (b) Reading, discussion and action upon each conclusion separately.
- (c) Reading and discussion of each item, if so decided by majority vote.

C-9. Recommended action on each report or section of a report at the Annual Meeting will be one of the following:

- (a) Acceptance as information.
- (b) For discussion.
- (c) Acceptance for submission to letter ballot for inclusion in the Manual.
- (d) Acceptance for submission to letter ballot superseding subject matter in the Manual. (Designate subject matter to be superseded.)
- (e) Acceptance for submission to letter ballot for elimination from the Manual.

C-10. Items Accepted for Letter Ballot. Following the Annual Meeting, committees having submitted reports which were accepted for submission to letter ballot will act promptly on the written comments and discussions presented at the Annual Meeting and submit reports, as revised, to the Secretary. Where major revisions are made in reports beyond the scope indicated by the discussion or affecting policy, copies of such revised reports, with copies of comments and discussions, shall be submitted to the Committee of Direction for its approval before submission to letter ballot for inclusion in the Manual.

D—Style Standards

D-1. Material for the Communication Manual shall be prepared in accordance with Appendix A, pages 17 to 20, inclusive.

D-2. Material for the Signal Manual shall be prepared in accordance with Appendix B, pages 21 to 34, inclusive.

D-3. Reports should be written preferably from the impersonal viewpoint. For example: "The capacity is calculated, etc.," is preferable to "I calculate the capacity, etc." or "You calculate the capacity, etc." The same form of address should be adhered to throughout; that is, a change from first to third person, etc. is to be avoided.

D-4. Where manufacturers' names and code numbers are used in requirement specifications the term "or approved equivalent" shall follow.

D-5. Committees and subcommittees in drafting specifications, where necessary, shall use the term "manufacturer" rather than the word "seller" or "supplier."

D-6. Line Drawings. Drawings prepared by committees must be forwarded to the Secretary in a form suitable for transmittal to the printer without further processing.

D-7. All drawings for the Manual should be arranged to permit of easy reading when reduced to the standard size printing area. Blueprints should not be sent in for engraving; the original tracing should be submitted.

D-8. The cross section lines of curves should not extend outside of the rectangle which encompasses the two base lines and the extreme points of the curves.

D-9. Photographs. Photographs should be glossy black and white prints, preferably unmounted. Photostats and blueprints cannot be reproduced satisfactorily.

D-10. Drawing Numbers. Numbers for all Manual drawings, plans, sketches and illustrations shall be furnished by the Secretary.

D-11. Definitions, Terms, Nomenclature and Graphical Symbols recommended in the Manual should be used.

D-12. When definitions of commonly used electrical terms are included in reports they shall conform to applicable ASA Definitions for Electrical Terms, C-42, latest revision.

D-13. When symbols are used for designating electrical quantities, use those recommended in ASA Letter Symbols for Electrical Quantities, Z10.5, 1949, or latest revision thereof.

D-14. Spelling and Abbreviations. General. In the preparation of reports it is desired that abbreviations, symbols, spelling of simple and compound words, capital letters, numerals, etc., shall conform as far as practicable to the ASA Standards. The usage of Webster's New International Dictionary will govern in all cases not otherwise provided for herein.

D-15. The word "percentage" shall be used when not following a number. Thus, "The percentage of copper shall be;" not "The percent of copper shall be." The word percent shall be used when following a number, as "0.035 percent copper."

D-16. Capitals. Both parts of a hyphenated word are capitalized in a title or caption when both words are complete words in themselves, but when the first part of a hyphenated word is a prefix the second part would not be capitalized. Examples: "Two-Ply; Non-loaded."

D-17. Use initial capitals in reference to Drawings, Figures, Tables, etc., as "Drawing C-1023, Fig. 12, Table 4." Use small initial letters for paragraph and page references such as paragraph C-4, page 106."

D-18. Abbreviations. Abbreviations should be used sparingly in text and with due regard to the context and to the training of the reader. Terms denoting units of measurement should be abbreviated in the text only when preceded by the amounts indicated in numerals; thus, "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings and texts for special purposes, the use of abbreviations should be governed only by the desirability of conserving space.

D-19. A sentence should not begin with a numeral followed by an abbreviation.

D-20. Short words such as ton, day and mile should be spelled out.

D-21. Abbreviations should not be used where the meaning will not be clear. In case of doubt, spell out.

D-22. The use of conventional signs for abbreviations in text is not recommended; thus, "per" not /, "lb." not #, "in." not ", "percent" not %. Such signs may be used sparingly in tables and similar places to conserve space.

D-23. The letters of such abbreviations as AAR should not be spaced (not A. A. R.).

D-24. The use in text of exponents for the abbreviations of square and cube and of the negative exponents for terms involving "per" is not recommended. The superior figures are usually not available on the keyboards of typesetting and linotype machines and composition is therefore delayed. There is also the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and are sometimes difficult to avoid in text.

D-25. In expressing dimensions use the following form: "2 in. by 4 in.;" not "2 in. x 4 in."

D-26. After numerals use the following abbreviations: 62 F, 36 C; in a table heading, use "Temperature, deg. Fahr." or "deg. Cent."

D-27. Abbreviations should conform to American Standards Abbreviations for Scientific and Engineering Terms, Z10.1—1941, or latest revision thereof.

D-28. Terms when used in an abstract or descriptive sense shall not be abbreviated. For example, use "the magnetomotive force is applied;" not "the mmf is applied."

D-29. Numerals. Spell out all numbers from one to ten, with the following exceptions:

(a) Use numerals when quantity is partly or wholly fractional, as "1.15, $1\frac{1}{2}$, $\frac{1}{8}$."

(b) Use numerals when followed by an expression having standard abbreviations, as "1 in., 6 lb.," except where the statement is vague in nature, in which case neither numerals nor abbreviations shall be used, as "about six pounds," etc.

(c) If for any reason the standard abbreviation of the expression following the number is not used, or if the expression does not admit of abbreviation (as ohm, ton, etc.) the use of numerals shall be optional, unless covered in the following paragraphs.

(d) In contrasted statements, if some numbers be numerals, use numerals for all, as "7 miles and 125 miles."

(e) If in a group of numbers some consist of three digits and others of less, use figures for all; e.g., "The packages contained, respectively, 10, 25 and 100 sheets;" not "ten, 25 and 100."

D-30. In a series of connected numerical statements implying precision, use numerals, as "2 years, 5 months, 3 days." The use of numerals (especially the "1") is not recommended for numbers occurring in precise statements sim-

ilar to the following: "By connecting one test coil;" "shall consist of two equal and uniformly wound solenoids," etc.

D-31. Use numerals after abbreviations, as "Vol. 6, Fig. 2," etc.

D-32. Use numerals for all numbers exceeding ten, with the following exceptions:

- (a) Never begin a sentence with a numeral.
- (b) Round numbers used in an indefinite sense shall be spelled out, as "a hundred feet or so," etc.
- (c) Numbers are spelled out where the use of numerals may be confusing: "Ten 2-inch rods," etc.
- (d) In expressing percentages, precise figures, etc., use decimals, as "4.5 percent," not "4½ percent."
- (e) In decimal numbers having no units, a cipher shall be placed before the decimal point, as "0.65 in.," not ".65 in."
- (f) In pointing off numbers of more than four figures, use commas in the text (1,234,567) and spaces in tabular matter (1 234 567). Numbers of four figures shall not be pointed off in the text (1234), but shall be in tabular work (1 234).

D-33. "Approved Types," "Approved Methods" and "Approved Equivalents" shall mean types of apparatus, methods and equivalents approved by this Section or other Divisions or Sections of the Operations and Maintenance Department of the AAR.

D-34. Use the singular form of the word "specification" in titles, as "Specification for"

D-35. Phrases and Words.

- (a) Use phrases:
 - In accordance with. (Reports.)
 - Conform to. (Drawings.)
- (b) Use the words:
 - May, in optional cases.
 - Must, in imperative cases, in Rules and Instructions.
 - Shall, in imperative cases, in Specifications and Requisites.
 - Should, in desirable cases.
 - Will, where reference is made to Purchaser's responsibility.
 - Recommended practice, not "standard."

Appendix A**STANDARD SECTIONS FOR USE IN PREPARING
REQUIREMENT SPECIFICATIONS—COMMUNICATIONS***

(Title)

(This outline can be elaborated upon or modified to suit the requirements of the apparatus to be specified. In general, however, it is recommended that the outline be followed as closely as practicable so that there will be uniformity in specifications.)

A—Purpose

A-1. The purpose of this specification is to guide the manufacturer in the supplying of.....for use in the communication plant.

B—Drawings and Specifications

B-1. Drawings included and referred to:

(Insert list of drawings)

B-2. Specifications referred to:

(Insert list of specifications)

C—General

C-1. The text of this specification and the specifications and drawings referred to under Section B are intended to supplement each other, so that any detail indicated in one and not in the other shall be executed the same as if indicated in both, unless exceptions are specifically mentioned within the body of this specification.

D—Material and Workmanship

D-1. Material and workmanship shall be first-class in every respect.

(Insert Body of Specification)

E—Dimensions

E-1. All dimensions shall be within the tolerances specified. Where allowable variations are not shown, reasonable correspondence to specified dimensions is required, consistent with good commercial practice.

F—Identification

F-1. Where necessary, the product shall be plainly marked with AAR code number or manufacturer's reference. (Otherwise this section may be omitted.)

* In these Standard Sections, the term "Manufacturer" shall be used to refer to the actual manufacturer or supplier, the supplier being considered the manufacturer's agent. The term "Contractor" shall be used to refer to an installer. The term "product" shall be used to refer to the item covered by the specifications. The term "material" shall be used to refer to the substances or parts of which the product is produced or fabricated.

G—Inspection and Tests

G-1. The purchaser shall have the right to make such inspection and tests as required to determine ifmeets the requirements of this specification. The inspector for the purchaser shall have the right to rejectwhich are defective in any respect.

G-2. Tests may be made at place of production, or on samples submitted, or at destination as specified by the purchaser.

G-3. When tested or inspected at place of production, the manufacturer shall furnish the purchaser's inspector with all reasonable facilities and necessary assistance without additional cost to the purchaser.

G-4. The manufacturer shall pay charges for handling, storage and freight both ways onrejected from lots shipped subject to inspection at destination. The manufacturer shall be notified immediately regarding the receipt of any defectiveand shall advise concerning their disposition.

Note to Committees: Following alternate section G to be used where applicable, instead of paragraphs G-1 to G-4, inclusive:

Alternate Section G.

G-1. The product furnished under this specification may be accepted upon manufacturer's certification that it is in accordance with the specification. If on arrival at destination the product is found not to meet the requirements of the specification it may be rejected and manufacturer, upon request, shall advise purchaser what disposition is to be made of the rejected product. Manufacturer shall pay all freight charges.

H—Packing

H-1. Product shall be so assembled or packed as to permit convenient handling and to protect against loss or damage during shipment.

Note to Committees: Where the product is to be furnished in bags, drums, cans, etc., the requirements of such containers shall be set forth in a separate section headed "Containers."

J—Markings

J-1. Purchaser's order, requisition and package number, name of consignor, and name and address of consignee, shall be plainly marked on outside of packages and on tags attached to loose pieces.

J-2. Detail list of loose pieces, packages and their contents shall be furnished for each shipment. Where carload shipments are made, routing and car identification shall be shown.

K—Warranty

K-1. (Except Cable.) The manufacturer shall warrant that the product, including all accessories and replacement parts, supplied in accordance with this specification shall be free from defects in design, material or workmanship under ordinary use and service withinfrom date of accept-

ance. This warranty shall not apply to any product which shall have been repaired or altered in any way by anyone other than the manufacturer thereof, so as to affect, in manufacturer's judgment, its proper functioning or reliability, nor to that which has been subjected to misuse, negligence or accident.

K-1. (Cable.) Manufacturer shall guarantee that, for a period of..... from date of installation, cable will be free from defects in design, material or workmanship. In event of failure, manufacturer shall allow return of defective cable for full credit or will replace in kind free of charge f.o.b. destination of original shipment. In latter case replaced cable shall become property of manufacturer at said destination, but purchaser shall not be held responsible for any damage to defective cable in removing or rereeling it. Manufacturer's obligation under this warranty shall not apply to any cable which has been subjected to misuse, negligence or accident after acceptance.

K-2. The manufacturer shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents or for patent royalties involved, in consequence of the purchase or use of the material covered hereby.

FORM FOR COMMUNICATION DRAWINGS

Tracings

Size of sheet should be $8\frac{1}{2}$ inches by 14 inches.

Size of area for illustration 8 inches wide by 13 inches high.

Notes

The size of the printed area of publications of the Section is 4 inches by $7\frac{1}{4}$ inches. Illustrations should be prepared 8 by 13 allowing for 50 percent reduction. The remaining $\frac{3}{4}$ inch to be used for titles, drawing numbers and dates approved, usually shown on the bottom.

Small illustrations to utilize only a part of the page should be kept within the eight inch dimension for width and the height should be planned to produce a balanced plate.

Large size illustrations to be printed on an insert sheet should be increased proportionately in width for the desired reduction. The Secretary should be requested for information as to size of tracing in order that proper reduction can be made.

Keep in mind that the finished cut must fit the page space and

- (a) Avoid crowded details, also, very fine lines or lines close together.
- (b) Avoid great contrast in weight of lines.
- (c) Do not use colored inks or diluted black ink.
- (d) Avoid pencil shading.
- (e) Cross section page with more than ten spaces to the inch will not reproduce.

Lettering:

- (a) Use vertical, plain, unshaded lettering.
- (b) Do not make lettering too heavy.
- (c) Never underline lettering.
- (d) Do not get letters or figures too close to the line work; they may run together in reproduction.
- (e) All lettering on any drawing should be the same size except that subtitles may be made 50 percent larger.
- (f) Main titles and numbers of illustrations are set in type; consequently legibility is the only requisite for the title shown on the drawing.

Form for Communication Drawings

C-1023

October, 1919; January, 1961

Appendix B

PREPARATION OF SIGNAL REQUISITES, SPECIFICATIONS,
INSTRUCTIONS, DRAWINGS, ETC.

1. REQUISITES—SIGNAL

(a) Definition of requisites.

1. A list in detail of all items which are essential or indispensable to a product, process or installation.
2. A list in detail of all items which are essential or indispensable to an operation affecting signaling which may include instructions relating to the use of these items.

(b) Preparation of requisites.

1. Requisites must be so drawn as to prescribe the essential requirements for the design or application of apparatus, materials, processes, circuits, or systems.
2. Requisites must be identified:

SIGNAL REQUISITES

(Title)-----
(Year presented to the Section)

3. The year of presentation to the Section of the entire subject-matter or subsequent thereto of any part or parts of the requisites must be placed under the title.

4. A paragraph explaining the intent of the requisites must be provided in all cases as Requisite 1, worded: "These requisites are for the purpose of setting forth the recommended general requirements for They set forth specific detail requirements representing modern signal practice recommended for new installations and for replacement of existing installations when general renewal or replacement becomes desirable." Where subheadings are used in the requisites, this paragraph shall appear under subheading "Purpose."

5. Reference to other requisites in the Manual must be made, when required, by title and Manual Part number.

6. Reference to specifications in the Manual should be made, when required, by specification number (without the last two digits), and Manual Part number.

7. Reference to ASTM or ASA specifications should be made, when required, by naming the specification as "current" and omitting the date reference; i.e., "in accordance with ASTM current Specification B 33," or "in accordance with current American Standard B8, issued by the American Standards Association."

8. Observe Rule D-35 with regard to phrases and words.

2. SPECIFICATIONS—SIGNAL

(a) Definitions of unit and major specifications.

1. Unit specification: A specification, in detail, of a given unit used in signal systems. It must meet the requirements of such signal requisites as are applicable.

2. Major specification: A specification covering a signal system, in detail, as to labor, material, transportation, etc.

(b) Preparation of specifications. (Unit and Major.)

1. Specifications must be so drawn as to prescribe the general requirements for safety, reliability, economy and limiting dimensions, but must not, as a general proposition, cover the detail design of detail parts of the apparatus.

2. Each specification will be given a two-part number. The first part being the specification's numerical designation and will be assigned by the Secretary. This will be followed by the last two digits of the year of presentation of the specification to the Section, thus:

SIGNAL SPECIFICATION 271-61

.....
(Title)

3. When a specification is revised, the number of the specification, with the exception of the last two digits indicating the year of presentation to the Section, must be retained.

4. Each section of a specification must contain the committee's recommendation; alternates must be shown in the alternate requisites section.

5. The following sections must not appear in Major Specifications as they are covered in Forms of Construction Contract, Proposal, and Bond:

- (a) Proposals.
- (b) Contract.
- (c) Changes and additions.
- (d) Material and workmanship.
- (e) Inspection of material.
- (f) Supervision.
- (g) Precautions.
- (h) Use of hand and other cars.
- (i) Warranty.

6. Each section of the specification for which there is an alternate must have placed at the end an asterisk (*) calling attention to a footnote to be placed at the bottom of each page on which the asterisk appears, reading: "*Alternate requisites section."

7. The specification and alternate must be written as shown in the following example:

6. Design.

- (a) Height of lock, for switch, from point of support shall be 4 ft. *R-6-a.

* Alternate requisites section.

Alternate Requisites

R-6-a.

Height of lock, for switch, from point of support shall be ft.

8. Sections shown in "General Provisions for Use in Major Specifications" must be copied into the Major Specifications as written in so far as they apply.

9. Sections shown in "Standard Sections for Use in Unit Specifications" must be copied into all Unit Specifications, wherever applicable, in whole or in part, and as directed by related "notes" appearing therein.

10. Reference to other specifications in the Manual should be made, when required, by specification number (without the last two digits), and Manual Part number.

11. Reference to requisites in the Manual must be made, when required, by title and Manual Part number.

12. Reference to ASTM or ASA specifications should be made, when required, by naming the specification as "current" and omitting the date reference; i.e., "in accordance with ASTM current Specification B 33," or "in accordance with current American Standard B8, issued by the American Standards Association."

13. Observe Rule D-35 with regard to phrases and words.

3. INSTRUCTIONS—SIGNAL

(a) Definition of instructions: A list in detail of all items which are essential or desirable for the proper installation, maintenance and test of products, processes or systems affecting signaling.

(b) Preparation of instructions.

1. Instructions must be identified:

SIGNAL INSTRUCTIONS

.....
(Title)

.....
(Year presented to the Section)

2. If, in any of the details a reference is made to "as instructed," an asterisk (*) should be made a suffix to the title and explained by footnote as follows: *The term "as instructed" as used herein refers to individual railroad instructions.

3. The year of presentation to the Section of the entire subject-matter or subsequent thereto of any part or parts of the instructions is to be placed under the title.

4. A paragraph explaining the intent of the instructions must be provided in all cases as a first paragraph, without number, worded:

"These instructions apply to the installation, maintenance and test of They set forth general requirements representing recommended practice."

5. Each paragraph, following the introductory paragraph, must be an instruction paragraph and numbered consecutively.

6. In so far as practicable, instructions must include the following:

(a) Maintenance, tests and repair work which may interfere with safe operation of trains must not be started until train movements have been fully protected. Temporary repairs or adjustments, when required, must be made in such manner that safety of train operation will not be impaired. When repair, adjustment, change or replacement is made, tests must be made immediately to determine that the apparatus functions as intended. When making tests of apparatus, proper instruments must be used and it must be known that no unsafe conditions are set up by the application of testing equipment.

(b) Before removing rails, switch points or frogs, protecting signals must be secured to display their most restrictive indication. Signals must not be restored to normal operation until tests have been made and it is known that they function as intended and that the track is safe for train operation.

(c) Each circuit, the functioning of which affects the safety of train operation, except circuit which includes any track rail must be kept free of any ground or combination of grounds as instructed. In no case shall a flow of current be permitted which is equal to or in excess of 75 percent of the release value of any relay or other electro-magnetic device in the circuit.

7. Reference to other instructions in the Manual, or to requisites, must be made, when required, by title and Manual Part number.

8. Reference to specifications in the Manual must be made, when required by specification number (without the last two digits), and Manual Part number.

9. Observe Rule D-35 with regard to phrases and words.

4. DRAWINGS—SIGNAL

(a) Drawings must be prepared in accordance with Drawing 6789. (See page 25.)

(b) In the interchange of revised drawings between members when colors are used to show changes, yellow shall indicate additions and red, removals.

(c) Drawing numbers will be assigned by the Secretary.

5. FORMS (Data Sheets)—SIGNAL

(a) Forms (data sheets) must be prepared in accordance with Drawing 6790. (See page 26.)

(b) Numbers for these sheets will be assigned by the Secretary.

**GENERAL PROVISIONS FOR USE IN
MAJOR SPECIFICATIONS—SIGNAL***

Note to Committees: The following footnote should appear on the first page of all major specifications:

Note—The recommended forms of construction contracts and bond will be found in the Manual of the American Railway Engineering Assn., Chapter 20—Contract Forms, Part 1.

1. Purpose

(a) This specification is for the purpose of providing for the installation of It sets forth specific detail requirements representing modern signal practice recommended for new installations and for the replacement of existing installations when general renewal or replacement becomes desirable.

2. Details of Work

(a)
.....
.....

3. Requisites, Specifications, Drawings, etc.

(a) Requisites, specifications, drawings, etc., referred to in the body of this specification form an essential part hereof.

(b) Purchaser's drawings should include the following:

1.
2.

(c) Contractor's drawings.

1.
2.

(d) Contractor shall furnish with his tender, drawing forming an essential part thereof.

(e) After award of the contract and before work is begun, contractor shall furnish for the approval of purchaser the following drawings as scheduled by purchaser:

1.
2.

Note to Committees: For section 3, the subheading and section 3-a should mention only the items referred to in the body of the specification.

4. Furnished by Purchaser

(a) Purchaser will obtain necessary permits from Federal, State and Municipal authorities.

* In major specifications, the word "material" is used as the general word "material," as differentiated from its use in unit specifications.

4. *Furnished by Purchaser—Continued*

(b) Purchaser will furnish, as indicated in sections 4-c, d and e, material or labor, or both, on the following items.

1. Ties for support of apparatus.
2. Move ties as may be necessary.
3. Move switch and tie rods as may be necessary.
4. Insulated rail joints.
5. Bridge insulations.
6. Switch-rod insulations.
7. Tie-rod insulations.
8. Gage-plate insulations.
9. Concrete material:
 - (a) Cement.
 - (b) Sand.
 - (c) Stone.
 - (d) Water.
10. Necessary grading and drainage.
11. Excavation of solid rock.
12. Poles for line wire.
13. Cross-arms, pins, insulators and fittings.
14. Line wire.
15. Battery housings.
16. Signal bridges.
17. Cables:
 - (a) Aerial.
 - (b) Submarine.
 - (c)
 - (d)
18. Conduit:
 - (a) Main.
 - (b) Branch.
 - (c)
 - (d)
19. Apply necessary attachments to signal apparatus in service.
20. Make necessary alterations of any part of existing structures or apparatus.
21. Unload and properly house material that arrives on the ground before Contractor's force; this work to be done under the supervision of Contractor's representative.
22. Distribute material.
23. Switches, derails and movable point frogs of the required throw.
24. Tools, fixtures for building and supplies required for the maintenance of the system.
25. Rail braces, except those located on gage plates installed by Contractor.
26. Submarine air pipe line.
27. Prior to installation, furnish stakes establishing grade of track at points where pipe lines are to be run.

(c) Material only on items.....

4. *Furnished by Purchaser—Continued*

- (d) Labor only on items.....
- (e) Material and labor on items.....
- (f) Purchaser will furnish the items as indicated in sections 4-c, d and e, subject to inspection of contractor, who shall state any objections thereto before starting his part of the work. After rectification by purchaser of any defects reported, contractor shall assume full responsibility for the proper functioning of the installation. The intent of this section is to bar any claim by contractor that the work done by purchaser has not been performed in such manner as to enable him to fulfill all the provisions of the contract.

5. *Alternates*

(a) The provisions contained in the alternate requisites section of this specification form a part hereof only when substituted by purchaser's order for the provisions contained in this specification.

(b) Where blanks have not been filled, or where an option is permitted and no preference stated, contractor's recommended practice shall be followed.

Note to Committees: Methods or materials other than specified in various sections will be listed in the alternate requisites section. Alternate requisites sections must be complete.

6. *Shipment of Material*

- (a) Materials shall be shipped to....., care of....., marked for..... . Material shipped from contractor's factory at.....shall be shipped via..... and thence via.....to destination.

7. *Transportation*

(a) Purchaser will furnish transportation for men, necessary for the installation, over the following lines (*R-7-a):

1.
2.

(b) Purchaser will furnish transportation for tools and material, necessary for the installation, over the following lines (*R-7-b):

1.
2.

Alternate Requisites*R-7-a.**

Contractor will furnish transportation for men, necessary for the installation, over the following lines:

1.
2.

R-7-b.

Contractor will furnish transportation for tools and material, necessary for the installation, over the following lines:

1.
2.

8. *Inspection of Installation*

(a) Contractor shall advise purchaser.....days in advance of the time installation will be completed and ready for final inspection. Purchaser will make inspection and tests within.....days after completion of the work.

9. *Tests*

(a) Contractor shall make such tests as may be necessary to demonstrate, to the satisfaction of purchaser, that the apparatus, as installed, is in accordance with the requirements of the specifications and contract. These tests, unless otherwise specified, shall include the tests shown in section 9-b and shall be conducted in accordance with AAR Signal Instructions for testing, where applicable, otherwise as directed by purchaser. Contractor shall provide such instruments and apparatus as may be necessary for making tests. Instruments and apparatus shall remain the property of contractor.

(b) The following tests shall be made:

Note to Committees: List here the tests which, in your opinion, are necessary to demonstrate to the satisfaction of the purchaser that the apparatus as installed is in accordance with the requirements of the specification and contract.

10. *Placing in Service*

(a) After receipt of written authority from purchaser, contractor shall place the installation in service under supervision of purchaser, and shall leave.....competent men on duty for.....days thereafter. *R-10-a.

(b) Signal aspects shall be displayed or changed only as authorized by purchaser.

*Alternate Requisites

R-10-a.

Purchaser will place the installation in service in the event that he does not authorize contractor to do so within.....days after completion of the work to purchaser's satisfaction.

11. *Completion*

(a) When installation is completed, apparatus and surface of the ground which has been affected by the installation, shall be left in a neat and clean condition.

12. *Clearances*

(a) Clearances shall conform to clearance diagram furnished by purchaser.

STANDARD SECTIONS FOR USE IN
UNIT SPECIFICATIONS—SIGNAL*1. *Purpose*

- (a) This specification is for the purpose of providing for.....

It sets forth specific detail requirements representing modern signal practice recommended for new installations and for replacement on existing installations when general renewal or replacement become desirable.

2. *Requisites, Specifications, Drawings, Etc.*

- (a) Requisites, specifications, drawings, etc., referred to in the body of this specification form an essential part hereof.

- (b) Manufacturer shall furnish with his tender, drawings forming an essential part thereof.

Note to Committees: For section 2, the subheading and section 2-a should mention only the items referred to in the body of the specification.

Section 2-b to be omitted when it is definite that drawings will not form an essential part of the tender.

No separate list of drawings is to be indicated as forming an essential part hereof unless they are actually known to be an essential part of the specification.

3. *Tender*

- (a) The tender shall be for a product meeting the requirements of this specification in its entirety.

4. *Purchaser's Order Requirements*

- (a) The following additional requirements will be shown on purchaser's order:

1.
2.
3. Inspection and tests as required.
4. Alternate requisites as required.

Note to Committees: This section is only to appear in specifications where additional information, as supplied by the purchaser, is indicated in the body of the specification as being necessary. The blanks must be filled in by the committee as required and may be more or less than shown. Items 3 and 4 to be used only when required and must follow all other items.

* In these Standard Sections, the term "manufacturer" shall be used to refer to the actual manufacturer or supplier, the supplier being considered the manufacturer's agent. The term "contractor" shall be used to refer to an installer. The term "product" shall be used to refer to the item covered by the specifications. The term "material" shall be used to refer to the substances or parts of which the product is produced or fabricated.

5. *Alternates*

(a) The provisions contained in the alternate requisites section of this specification form a part hereof only when substituted by purchaser's order for the provisions contained in this specification.

Note to Committees: Methods or materials other than specified in various sections will be listed in the alternate requisites section. Alternate requisites sections must be complete.

6. *Material and Workmanship*

(a) Material and workmanship shall be first-class in every respect.

(Insert Body of Specification)

7. *Design*

Note to Committees: Under the design section, the committee will prescribe, when necessary, the general requirements for safety, reliability, economy and limiting dimensions, but must not as a general proposition, cover the design of detail parts of the apparatus unless essential.

8. *Binding Posts*

(a) Binding posts, nuts and washers shall conform to Drawing 1070.

(b) Binding posts shall be mounted so they cannot be turned in the base or frame to which applied. They shall be properly insulated from each other and other metallic parts.

9. *Coil Insulation*

(a) Coils shall be wound with insulated wire and treated so as not to be injuriously affected by atmospheric conditions or by changes in temperatures between 40 F below zero and 185 F above zero.

1. Wire shall be in accordance with Specification 193, Manual Part 183.

(b) Coils external to the housing of moving parts shall be impregnated by vacuum and pressure with insulating compound in accordance with Requisites for Compound for Impregnation of Electrical Windings, Manual Part 171.

(c) Coils adjacent to moving parts, armature air gaps or contacts shall be treated by impregnation or dipping with insulating varnish in accordance with Requisites for Varnish for Treatment of Electrical Windings, Manual Part 174.

(d) When enamel insulation on No. 16 AWG wire or smaller is used on impregnated coils, a cotton thread shall be placed between layers and built up at each end to a minimum wall thickness of $\frac{1}{16}$ in.

(e) Insulating material used for fillers in winding coils shall be chemically neutral.

(f) Coils shall be so insulated that they will withstand the insulation test provided in section 10. This test shall be made by mounting coil on a snugly fit metal mandrel and making breakdown tests between mandrel and winding; also by standing coil on each end in turn on a metal plate and testing between plate and winding.

10. *Dielectric Requirements*

(a) Electrical apparatus assembled shall withstand for one minute an insulation test, at place of manufacture, of**..... volts a-c between all parts of electric circuits and other metallic parts insulated therefrom.

(b) A surface leakage distance of not less than.....**.....in. shall be provided between any exposed metallic part of the apparatus carrying current and any other metallic part thereof.

(c) Separate windings, which are insulated from each other, shall withstand for one minute an insulation test of.....**.....volts a-c between their terminals.

(d) A potential of twice the normal operating requirements at a suitable frequency shall be impressed across the windings without any excessive flow of current indicating a short circuit.

****Note to Committees:** Show value for the particular apparatus.

11. *Identification*

(a) Magnet coils and resistors shall be plainly marked with Manufacturer's references.

12. *Inspection and Tests*

(a) The purchaser shall have the right to make such inspection and tests as required to determine if.....meets the requirements of this specification. The inspector for the purchaser shall have the right to reject.....which are defective in any respect.

(b) Tests may be made at place of production, or on samples submitted, or at destination as specified by the purchaser. Purchaser shall indicate which of the tests herein specified are to be made and what portion of the material or product shall be tested.

(c) When tested or inspected at place of production, the manufacturer shall furnish the purchaser's inspector with all reasonable facilities and necessary assistance without additional cost to the purchaser.

(d) The manufacturer shall pay charges for handling, storage and freight both ways on.....rejected from lots shipped subject to inspection at destination. The manufacturer shall be notified immediately regarding the receipt of any defective.....and shall advise concerning their disposition.

Note to Committees: Following alternate section 12-a to be used where applicable, instead of sections 12-a to 12-d, inclusive:

Alternate Section 12-a.

(a) The product furnished under this specification may be accepted upon manufacturer's certification that it is in accordance with the specification. If on arrival at destination the product is found not to meet the requirements of the specification it may be rejected and manufacturer, upon request, shall advise purchaser what disposition is to be made of the rejected product. Manufacturer shall pay all freight charges.

13. *Packing*

(a) Product shall be so assembled or packed as to permit convenient handling and to protect against loss or damage during shipment.

Note to Committees: Where the product is to be furnished in bags, drums, cans, etc., the requirements of such containers shall be set forth in a separate section headed "Containers."

14. *Marking*

(a) Purchaser's order, requisition and package number, name of consignor, and name and address of consignee, shall be plainly marked on outside of packages and on tags attached to loose pieces.

(b) Detail list of loose pieces, packages and their contents shall be furnished for each shipment. Where carload shipments are made, routing and car identification shall be shown.

15. *Warranty*

(a) *Except Cable.* The manufacturer shall warrant that the product, including all accessories and replacement parts, supplied in accordance with this specification shall be free from defects in design, material or workmanship under ordinary use and service within.....from date of acceptance. This warranty shall not apply to any product which shall have been repaired or altered in any way by anyone other than the manufacturer thereof, so as to affect, in manufacturer's judgment, its proper functioning or reliability, nor to that which has been subjected to misuse, negligence or accident.

(b) *Cable.* Manufacturer shall guarantee that, for a period of.....from date of installation, cable will be free from defects in design, material or workmanship. In event of failure, manufacturer shall allow return of defective cable for full credit or will replace in kind free of charge f.o.b. destination of original shipment. In latter case replaced cable shall become property of manufacturer at said destination, but purchaser shall not be held responsible for any damage to defective cable in removing or rereeling it. Manufacturer's obligation under this warranty shall not apply to any cable which has been subjected to misuse, negligence or accident after acceptance.

(c) The manufacturer shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents or for patent royalties involved, in consequence of the purchase or use of the material covered thereby.

Exhibit B

COOPERATION WITH OTHER ORGANIZATIONS

	Representative
AAR—Joint Committee on Relation Between Track and Equipment in the study respecting the roll-ability of cars	C. T. Marak, Signal Engineer, Missouri Pacific Railroad.
AAR—Joint Committee on Clearances	J. A. Balla, Engineer Communications and Signals, Pennsylvania Railroad.
AAR—Joint Committee on Metric System	L. E. Kearney, Engineer Communications and Signals, Communication and Signal Section, AAR.
AAR—Collaboration between Divisions and Sections	A. H. Grothmann, Secretary, Communication and Signal Section, AAR.
AAR—Mechanical Division	
Committee on Car Construction (car designs—dimensions and clearances)	J. A. Balla, Engineer Communications and Signals, Pennsylvania Railroad.
Joint Subcommittee on ability of off-tread brakes on freight cars to adequately shunt track circuits	V. S. Mitchell, Signal Engineer, Chicago & North Western Railway.
AREA—(Engineering Division)	
Committee 1—Roadway and Ballast	
Reflectorized and Luminous Roadway Signs	A. L. Essman, Chief Signal Engineer System, Burlington Lines.
Chemical Control of Vegetation	J. R. Sterling, Superintendent Communications, Southern Railway System.
Committee 4—Rail Joint Bar Wear and Failures	C. J. R. Taylor, Office Engineer, Communications and Signal Department, Erie-Lackawanna Railroad.
Committee 5—Track	C. J. R. Taylor, Office Engineer, Communications and Signal Dept., Erie-Lackawanna Railroad.
Committee 9—Highways	P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR.

Representatives

Committee 15—Iron and Steel Structures	P. H. Foley, Assistant Engineer Communications and Signals Communications and Signal Section, AAR.
Committee 18—Electricity	F. L. Chatten, System Engineer—Communications and Signals, Pennsylvania Railroad.
Committee 28—Clearances	J. A. Balla, Engineer Communications and Signals, Pennsylvania Railroad.
ASA—Standards Council	L. E. Kearney, Engineer Communications and Signals, Communication and Signal Section, AAR. P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR. (Alternate)
ASA—Sectional Committee on Standardization and Unification of Screw Threads, B1	C. J. R. Taylor, Office Engineer, Communications and Signal Department, Erie-Lackawanna Railroad.
ASA—Sectional Committee on National Electrical Safety Code, C2	E. M. Hastings, Jr., Wire Crossing Engineer, Chesapeake & Ohio Railway System. (AAR Rep.) F. R. Cummings, Assistant Engineer Signals, Chesapeake & Ohio Railway System. (AAR Alternate)
Subcommittees:	
Voltage Classification and Clearances	J. C. Ramage, Assistant Superintendent Communication, Illinois Central Railroad.
Strength Requirements and Loading	G. N. Loomis, Assistant Superintendent Communications, New York, New Haven & Hartford Railroad. A. B. Swartzwelder, Engineer Communications and Signals, Pennsylvania Railroad.
Grounding	R. L. Straw, Communications Engineer, New York Central Railroad. W. B. Johnson, Assistant Signal Engineer, Chicago, Rock Island & Pacific Railroad.

Conflicts and Interpretations

General Review

ASA—Sectional Committee on Insulated Wires and Cables (other than telegraph and telephone), C8

ASA—Technical Committee on Weather-Resistant Wire, C8.18

ASA—Sectional Committee on Dry Cells and Batteries, C18

ASA—Sectional Committee on Radio, C16

ASA—Sectional Committee on Lightning Arresters, C62

ASA—Sectional Committee on Radio-Electrical Coordination, C63

ASA—Sectional Committee on Electronic Components, C83

ASA—Sectional Committee on Wood Poles, O5

ASA—Sectional Committee on Graphical Symbols and Designations, Y32

Representatives

J. H. Wallis, Communications Engineer, Baltimore & Ohio Railroad.

R. W. Margsh, Signal Engineer, Chesapeake & Ohio Railway System.

P. S. Hughel, Superintendent Communication, New York Central Railroad.

V. O. Smeltzer, Superintendent Signals System, Atchison, Topeka and Santa Fe Railway.

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	Representatives
ASA—Sectional Committee on Electrical Standards Board, Communications and Electronics Section	L. E. Kearney, Engineer Communications and Signals, Communication and Signal Section, AAR.
ASTM—Committee A-5 on Corrosion of Iron and Steel	P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR.
ASTM—Committee B-1 on Wires for Electrical Conductors	P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR.
ASTM—Committee D-11 on Rubber and Rubber-Like Materials: Subcommittee V on Insulated Wire	P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR.
Subcommittee IX on Insulating Tapes	P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR.
ASTM—Committee D-7—Wood	J. R. Sterling, Superintendent Communications, Southern Railway System.
National Bureau of Standards—Standardization of Signal Light Colors	C. J. R. Taylor, Office Engineer, Communications and Signal Department, Erie-Lackawanna Railroad.
National Safety Council—Committee on Traffic Safety at Highway-Railroad Crossings	P. H. Foley, Assistant Engineer Communications and Signals, Communication and Signal Section, AAR.
Operational Fixed Microwave Council	L. E. Kearney, Engineer Communications and Signals, Communication and Signal Section, AAR. P. B. Burley (Chairman of Committee 4), Superintendent Communication and Electrical Engineer, Illinois Central Railroad.

REPORT OF
COMMITTEE 1—WIRE AND CABLE LINES

- J. D. MacQuarrie (Chairman), General Outside Plant and Standards Engineer, Canadian Pacific Railway.
R. W. Margsh (Vice-Chairman), Signal Engineer, Chesapeake and Ohio Railway.
W. W. Beard, Assistant Signal Engineer, Baltimore and Ohio Railroad.
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W. B. Johnson, Assistant Signal Engineer, Chicago, Rock Island and Pacific Railroad.
G. H. Kuhn, Assistant Engineer Signals and Communications, Wabash Railroad.
K. M. Lockerby, Engineer Signals and Catenary, Pennsylvania Railroad.
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G. J. Stonehouse, Signal Engineer, Grand Trunk Western Railroad.
R. L. Straw, Communications Engineer, New York Central Railroad.
C. H. Wesman, Assistant Engineer Signals and Communications, Great Northern Railway.

Consulting Members

- D. L. Baxter, Executive Engineer, Reliable Electric Company.
E. J. Bonnesen, Engineer, American Telephone and Telegraph Company.
E. A. Cooke, Assistant Transmission Engineer, The Western Union Telegraph Company.
J. B. Hays, Member, Technical Staff, Bell Telephone Laboratories, Inc.
A. T. Johnston, Consulting Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
R. J. Little, Standards Engineer, General Railway Signal Company.
J. L. Slater, Engineer, The Western Union Telegraph Company.
L. I. Wilson, General Supervisor of Lines, The Western Union Telegraph Company.
F. Woodland, Plant Structures Engineer, American Telephone and Telegraph Company.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.
3. Cooperate with Sectional Committee of the American Standards Association on the following:
 - (a) Specifications for Wood Poles, O-5.
4. Continue investigation of various methods of treating poles and timber used in communications plant.
5. Report work being done by railroads and other bodies on the subject of protection against electrolysis and soil corrosion.
7. Prepare specification for splicing plastic cables.
9. Investigate and report on the use and the desirability of plastic and other types of vibration dampers for use on line wires.
10. Investigate and report on use of new types of plastic wire insulation.
11. Investigate and report on insulation of splices in insulated wire.
14. Prepare a specification for thermoplastic sheathed cable with polyethylene insulated conductors for direct burial in earth.
15. Collaborate with AREA Committee 1—Railway and Ballast, in connection with its Assignment 11—Chemical control of vegetation.
16. Keep in touch with the development of protective devices and report to the Section on items that the committee feels would be of particular interest to the membership of the Section.
18. Investigate and report on recent developments in mitigating effects of line hits by modifying protection or other means.
19. Investigate and report on aerial cable with built-in messenger support for communication and signal use.
20. Investigate and report on the practicability of cable suitable for both communication and signal use.
21. Investigate and report on the use of Semper Seal in the damming of cables for pressurization and, if considered desirable, prepare specification or modification of existing specification for pressurization.

The committee submits for consideration, reports on the following subjects:

1. **Specification for Construction of Railroad Communication Pole Lines, 1-A-6.** This specification is undergoing current review and the following items are presented for consideration at this time.

Section C—Clearance for Poles and Attachments.

Paragraph C-3. The use of larger railroad cars such as tri-level automobile cars, has created clearance problems not contemplated when this specification was last revised. It is now required that side clearances be maintained somewhat in excess of those specified in paragraph C-3. Many member roads are confronted with this problem and to meet present operating requirements it is recommended that the side clearances specified in this paragraph be changed to read as follows:

- C-3.** Where practicable, a horizontal separation of at least eight feet from the inside of the nearest track rail shall be provided for all crossarms,

wires, cables, guys and other attachments. At points where it is impracticable to obtain such horizontal separation it will be necessary to provide vertical clearances between the lowest crossarm or attachment and the track level as follows:

Horizontal Separation (Feet)	Vertical Clearances (Feet)
8 to 3	22½
Less than 3	25

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

Section F—Fitting and Numbering Poles. Revisions in this section of 1-A-6, which it is deemed desirable be made at this time, together with revised drawings, are shown in Exhibit 1-A, page 44.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

Section H—Guys and Anchors. Revisions in this section of 1-A-6, which it is deemed desirable be made at this time, together with revised drawings, are shown in Exhibit 1-B, page 47.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

Section N—Guard Screen Construction. As this type of construction is no longer being used the committee recommends that this section be deleted.

Action Recommended

Acceptance for submission to letter ballot for elimination from the Communication Manual.

1. **Specification for Galvanized Copper Bearing Steel Tie Wires, 1-A-16,** as Exhibit 1-C, page 49. This is a reference sheet and the current ASTM specification has been reviewed and found acceptable. The sheet has therefore been corrected to show current ASTM standard.

Action Recommended

Acceptance for submission to letter ballot superseding 1-A-16 in the Communication Manual.

1. **Specification for Galvanized Steel Strand, 1-A-17,** as Exhibit 1-D, page 50. This is a reference sheet in the Communication Manual and the ASTM standard originally referred to has been revised. The revision has been reviewed and found acceptable and the sheet has been corrected to show current specification designations.

Action Recommended

Acceptance for submission to letter ballot superseding 1-A-17 in the Communication Manual.

1. General Specification for Galvanizing for Iron and Steel, 1-D-5, as Exhibit 1-E, page 51. This is a reference sheet in the Communication Manual and the ASTM standards originally referred to have been revised. The revisions have been reviewed and found acceptable and the sheet has been corrected to show current specification designations.

Action Recommended

Acceptance for submission to letter ballot superseding 1-D-5 in the Communication Manual.

1. Manual Parts to be eliminated from Signal Manual:

- 175—Copper Bond Wire
- 176—Copper-Covered Steel Bond Wire
- 177—Galvanized EBB Steel Bond Wire
- 187—Insulated Wire, AVC

As very few member roads use the foregoing wires the committee feels the specifications serve no useful purpose and therefore recommends their elimination from the Signal Manual.

Action Recommended

Acceptance for submission to letter ballot for elimination from the Signal Manual.

1. Signal Manual Part 183—Copper Magnet Wire. Due to the difficulty of keeping this specification up to date, in view of the rapid developments of new insulating material, it is recommended that it be eliminated from the Signal Manual.

Action Recommended

Acceptance for submission to letter ballot for elimination from the Signal Manual.

1. Signal Manual Part 186—Insulated Wire. It is recommended that the following new paragraph be included under section 8—Insulation, designated as section 8 (c), to follow Table II. Present section 8 (c) will be redesignated 8 (d).

8 (c). The average thickness of the insulation shall be not less than that prescribed in Tables I and II. The minimum thickness shall be not less than 95 percent of the specified thickness for insulation less than $\frac{1}{4}$ in., and not less than 90 percent of the specified thickness for insulations of $\frac{1}{4}$ in. and greater.

Action Recommended

Acceptance for submission to letter ballot for inclusion in the Signal Manual.

3. ASA Sectional Committee on Wood Poles, O-5. At meeting of ASA Committee O-5 in New York on November 20-21, 1961, significant progress was made in revision of ASA Specification O5.1-1948, American Standard

Oct. 1962]

Specifications and Dimensions for Wood Poles. The specification has been carefully reviewed and many changes recommended, primarily for updating the information in line with results of the ASTM pole testing program and to conform to present practices.

The revision appears to be about completed except for fiber stress designations for various species of southern pine. A special task force is working on this matter and a final decision is expected soon.

The revised specification, as now proposed, will change fiber stress values for Northern White Cedar from 4000 to 3600 lbs; Western Red Cedar from 6000 to 5600 lbs; Western Firs from 6000 to 6600 lbs; and Western Hemlock from 6600 to 7400 lbs. A number of new species will be added or stated separately.

A compromise was reached on elimination of certain pole classes and lengths from the tables by including as "standard" all pole sizes comprising 0.5 percent or more of the total production. Dimensions for other size poles will be retained but printed in lighter type as information.

Action Recommended

Acceptance as information.

4. Various Methods of Treating Poles and Timber Used in Communication Plant, as Exhibit 1-F, page 52.

Action Recommended

Acceptance as information.

5. Deep Anode Ground Beds, as Exhibit 1-G, page 53.

Action Recommended

Acceptance as information.

18. Recent Developments in Mitigating Effects of Line Hits by Modifying Protection or Other Means, as Exhibit 1-H, page 54.

Action Recommended

Acceptance as information.

20. Investigate and Report on the Practicability of Cable Suitable for Both Communication and Signal Use. This assignment was given careful consideration, at which time representatives of various wire and cable manufacturers were present. It was the consensus that the limited number of conductors, insulations and combinations that might lend themselves to joint usages would not justify the lowered standards of data transmission on communications circuits or the reliability and ruggedness of service on signal circuits. The committee will continue its study.

Action Recommended

Acceptance as information.

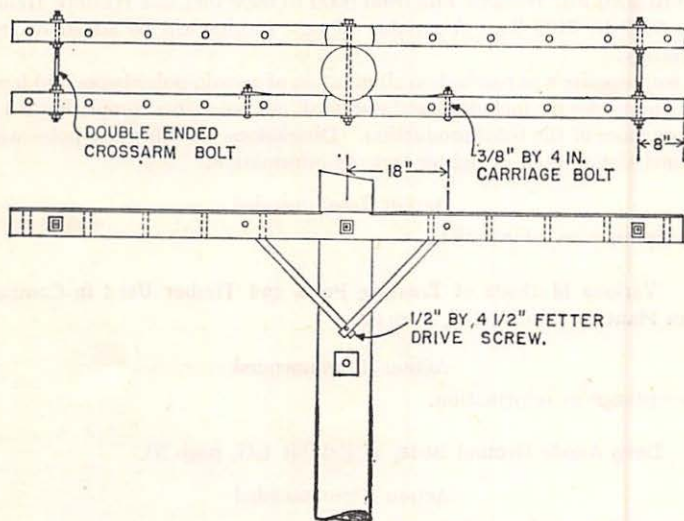
Respectfully submitted,

COMMITTEE 1—WIRE AND CABLE LINES

Exhibit 1-A

PROPOSED REVISIONS IN SECTION F OF 1-A-6

F-9. Double crossarms, except on "H" fixtures, shall be clamped together near each end with double-ended crossarm bolts equipped with four nuts and four $2\frac{1}{4}$ in. square washers as shown in Drawing C-2632.



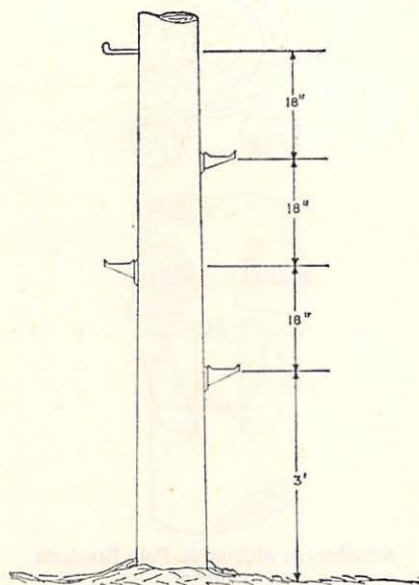
Method of Attaching Double Crossarms
C-2632

January, 1939; June, 1962

F-10. Where "H" fixtures are used at end terminals, the double crossarms should be clamped together at point midway between the poles of the fixture by means of double-ended crossarm bolts equipped with four nuts and four $2\frac{1}{4}$ in. square washers.

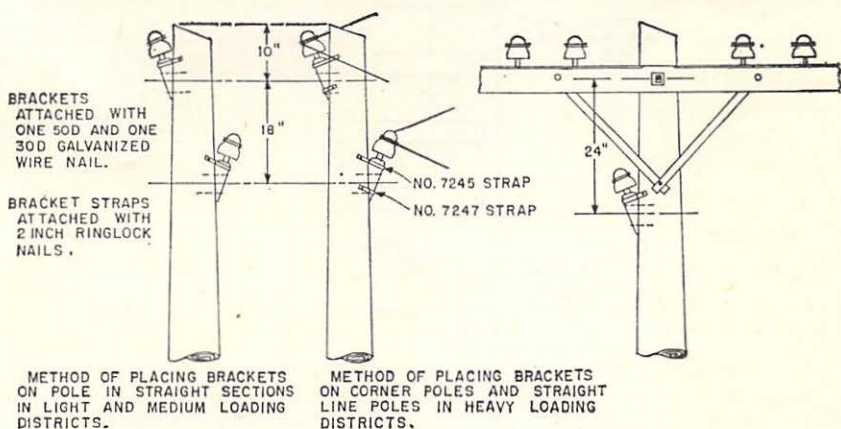
F-36. The normal spacing and arrangement of pole steps is shown in Drawing C-2644. Two standard wood steps shall be used at the lower end of the pole and standard steel steps for the remainder of the distance. The lowest wood step should not be less than three feet from the ground. Where railroad signal circuits of more than 150 volts are carried, the bottom step shall not be less than $3\frac{1}{2}$ ft. from the ground. Steps should normally be placed in line with the crossarms. On poles along city streets, however, the steps should be placed in line with the line for a distance of at least 15 feet above the ground.

Where state or local regulations provide that the lowest steel step on any stepped pole shall be not less than 7 ft. 6 in. from the ground line or other readily accessible places, detachable pole steps shall be used. The spacing and arrangement of detachable pole steps is shown in Drawing C-5075.

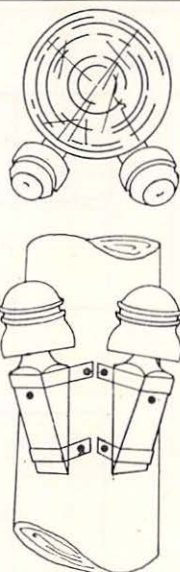


Arrangement of Detachable Pole Steps
C-5075
June, 1962

F-37. Wood pole steps shall each be secured by means of one 30-d and one 50-d galvanized wire nail. To prevent wood steps from pulling away from pole, bracket straps may be used as illustrated in Drawings C-2638 and C-2639.



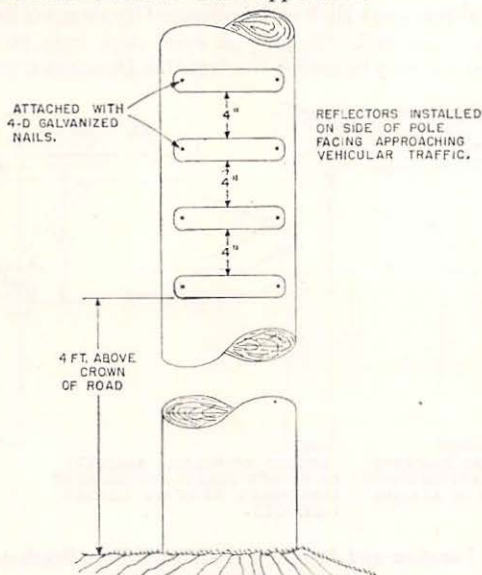
Location and Attachment of Wood Pole Brackets
C-2638
January, 1939; June, 1962



Attachment of Double Pole Brackets
C-2639

January, 1939; June, 1962

F-46. Where marking is required on poles situated along a street which carries heavy vehicular traffic, reflectors shall be installed on each pole as illustrated in Drawing C-2647. The reflectors should be placed on the side of the pole from which vehicular traffic approaches.



Arrangement and Spacing of Reflectors
C-2647

January, 1939; June, 1962

Exhibit 1-B

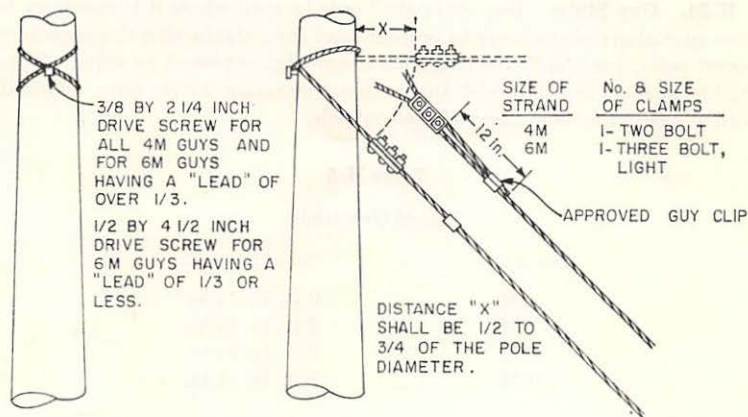
PROPOSED REVISIONS IN SECTION H—GUYS AND ANCHORS
OF 1-A-6

H-1. Guys. 4M, 6M, 10M and 16M galvanized steel strand are standard for use in guying pole lines.

H-2. In such situations, where experience has shown the life of galvanized steel strand to be unsatisfactory, a strand more resistant to corrosion may be used. Where such materials are employed for guys, consideration should be given to protecting the guy rod as specified in paragraph H-20.

H-10. Methods of Attaching Guys to Poles.

(1) **The Wrap Around Method.** The method of attaching 4M and 6M strand to poles is illustrated in Drawing C-2650. Drawing C-2651 illustrates the method of attaching 10M guys in all cases and 16M guys where guy hooks are not required. Drawing C-2652 shows the method to be used in attaching 16M guys where guy hooks are necessary.



The Wrap Around Method of Attachment of 4M and 6M Guys to Poles
C-2650

January, 1939; June, 1962

H-17. Log Anchors. Log anchors are furnished in the four following sizes: 4M, 6M, 10M and 16M and the dimensions of these log anchors are specified in Table H-4. These sizes should normally be employed for anchoring equivalent sizes of guy strand. In situations where the holding power of the soil is poor, special log anchors of extra size may be required.

Table H-4
Dimensions of Anchor Logs

Size of Guy	Designation of Anchor Log	Minimum Sizes of Round Logs		Minimum Sizes of Split Logs		Diam. of Rod Hole
		Length	Diam.	Length	Diam.	
4M	4M	3 ft. or 4 ft.	7 in. 6 in.	3 ft. or 4 ft.	8 in. 7 in.	$\frac{3}{16}$ in.
6M	6M	3 ft. or 4 ft.	8 in. 7 in.	3 ft. or 4 ft.	10 in. 8 in.	$\frac{11}{16}$ in.
10M	10M	4 ft. or 5 ft.	10 in. 8 in.	4 ft. or 5 ft.	11 in. 9 in.	$\frac{13}{16}$ in.
16M	16M	6 ft. or 7 ft.	10 in. 9 in.	6 ft. or 7 ft.	13 in. 11 in.	$1\frac{1}{16}$ in.

H-25. Methods of Attaching Guys. The method of attaching guys to standard thimble eye guy rods is illustrated in Drawing C-2656. Where guys are to be attached to existing rods which do not have the thimble eye, standard guy thimbles of the proper size should be used in all cases.

H-34. Guy Stubs. Guy stubs shall only be used where it is necessary to raise guys above obstacles or to prevent guys from obstructing thoroughfares. Sound poles, preferably treated, shall always be employed as stubs. They shall be as short as will furnish the necessary clearance for the guys, and shall normally be of the same class as the guyed pole.

Table H-5
Size of Guy Rods

Size of Guy	Size of Guy Rod
4M	6 ft. by $\frac{1}{2}$ in.
6M	7 ft. by $\frac{5}{8}$ in.
10M	8 ft. by $\frac{3}{4}$ in.
16M	8 ft. by 1 in.

Exhibit 1-C

**SPECIFICATION FOR GALVANIZED COPPER BEARING
STEEL TIE WIRES**

Superseded by

**STANDARD SPECIFICATIONS FOR ZINC-COATED (Galvanized)
STEEL TIE WIRES
(A-112-59 or current revision)**

Copies may be obtained from

**AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 RACE STREET
PHILADELPHIA 3, PA.**

Supplementary Specifications

Orders shall specify the gage, AAR warranty and that the tie wires shall be made from "Copper Bearing Steel."

Warranty

The seller/contractor shall warrant that the material furnished under this specification shall be free from defects in design, material and workmanship. The seller's/contractor's obligation under this warranty shall not apply to any material which has been subject to misuse, negligence or accident after acceptance.

The seller/contractor shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents, or for patent royalties involved, in consequence of the purchase or use of the material covered hereby.

Exhibit 1-D

SPECIFICATION FOR GALVANIZED STEEL STRAND

Superseded by

STANDARD SPECIFICATIONS FOR ZINC COATED STEEL WIRE
STRAND ("Galvanized" and Class A ["Extra Galvanized"])
(A-122-58 or current revision)

Copies may be obtained from

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 RACE STREET
PHILADELPHIA 3, PA.

Supplementary Specifications

Steel wire strand shall be ordered under ASTM Standard Specifications for Zinc Coated Steel Wire Strand A-122-58. In addition, the order shall specify the following:

Size and Type of Strand

7 wire, utilities grade—inch diameter strand should be specified.

NOTE: The following are standard railway communication sizes.

4M— $\frac{9}{32}$ in. diameter

6M— $\frac{5}{16}$ in. diameter

10M— $\frac{3}{8}$ in. diameter

16M— $\frac{7}{16}$ in. diameter

Preformed strand shall be specified if required.

Warranty

The seller/contractor shall warrant that the material furnished under this specification shall be free from defects in design, material and workmanship. The seller's/contractor's obligation under this warranty shall not apply to any material which has been subject to misuse, negligence or accident after acceptance.

The seller/contractor shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents, or for patent royalties involved, in consequence of the purchase or use of the material covered hereby.

Exhibit 1-E

GENERAL SPECIFICATION FOR GALVANIZING
FOR IRON AND STEEL

Superseded by

STANDARD SPECIFICATIONS FOR SLAB ZINC (Spelter)
(B-6-58 or current revision)STANDARD SPECIFICATIONS FOR ZINC COATING (Hot-Dip)
ON IRON AND STEEL HARDWARE
(A-153-60 or current revision)STANDARD METHODS OF TEST FOR WEIGHT OF COATING
ON ZINC-COATED (Galvanized) IRON
OR STEEL ARTICLES
(A-90-53 or current revision)STANDARD METHOD OF TEST FOR UNIFORMITY OF COATING
BY THE PREECE TEST (Copper Sulfate Dip)
ON ZINC-COATED (Galvanized) IRON OR STEEL ARTICLES
(A-239-41 or current revision)

Copies may be obtained from

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 RACE STREET
PHILADELPHIA 3, PA.

Supplementary Specification

Warranty

The seller/contractor shall warrant that the material furnished under this specification shall be free from defects in design, material and workmanship. The seller's/contractor's obligation under this warranty shall not apply to any material which has been subject to misuse, negligence or accident after acceptance.

The seller/contractor shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents, or for patent royalties involved, in consequence of the purchase or use of the material covered hereby.

Exhibit 1-F

VARIOUS METHODS OF TREATING POLES AND TIMBER
USED IN COMMUNICATION PLANT*

There are several compounds available for ground-line treatment of poles in place. All of these compounds are applied in a similar manner. The soil is removed from around standing poles approximately 18 inches in depth and dirt cleaned from pole. All the decayed wood should be removed by shaving before the preservative is applied. A preservative is then applied from 12 inches below the ground line to six inches above. Then a protective bandage is applied over the preservative and stapled to the pole to keep the preservative from moving into the soil rather than the wood.

Several utility and railroad companies have used this method of ground-line treatment of poles and it is suggested that it adds ten years of life to poles. It is recommended that any compound used for this purpose include the following minimum concentrations of preservative: 15 percent creosote, 15 percent sodium fluoride and 10 percent pentachlorophenol.

One railroad has approximately 43 miles of ground-line treatment and another, 58 miles. However, it is too early to say what benefits are to be gained by this treatment but both companies are planning to extend their program of ground-line treatment in the near future.

* For previous reports on this subject see Proceedings, Communications Section, 1951, pages 7 and 8; 1957, page 23; 1958, page 39.

Exhibit 1-G

DEEP ANODE GROUND BEDS

The AT&T Company recently completed a number of deep anode ground bed installations at Central Office Buildings near the center of several cities in Illinois. Underground telephone cables radiate from these buildings to the outskirts of the cities and are adjacent to other underground structures, some of which are relatively close to the Telephone Company duct system.

Holes six inches in diameter and approximately 300 feet deep were drilled in the street or between the sidewalk and curb for the ground beds.

Observations of the drill cuttings showed a penetration through layers of shale, fire clay, sandstone, limestone and coal. Resistivity measurements of the samples were made with a soil box and Vibroground. Variations in the resistivity of the samples ranged from 960 to 9200 ohms per centimeter cube.

Ten high silicon iron anodes, five feet long and three inches in diameter were attached, by steel straps at the top and bottom of each anode, to a one inch diameter steel pipe column 80 feet long and lowered into the hole to the lower resistance layer. Individual leads from each anode were brought to the surface for connection to the cathodic protection rectifier. Flake graphite was mixed with water and pumped into the one inch pipe and thence into the six inch hole through openings in the bottom of the pipe, to form the backfill around the anodes.

Tests showed the anode and cable sheath resistance at each of the four installations to be 1.5 ohms or less. At one location when a test current of 20 amperes was impressed on the anode, sheath potentials referred to a lead test electrode and in a vacant duct were reversed from approximately 0.1 volt positive to 0.1 volt negative in duct sections up to half a mile from the anode. Smaller but still appreciable benefits were found in ducts within one mile of the anode.

The potential of the sheath to a lead test electrode in the earth in the immediate vicinity of the anode did not exceed 2.0 volts negative.

To date, tests showed a minimum of interference current present on other structures.

Exhibit 1-H

REPORT ON RECENT DEVELOPMENTS IN
MITIGATING EFFECTS OF LINE HITS BY MODIFYING
PROTECTION OR OTHER MEANS

Hits caused by open wires swinging together can be eliminated by the use of insulated line wire. A survey indicates there is a noticeable trend among railroads toward increasing the reliability of open wire facilities by using insulated, high tensile strength wire.

Open wires can be kept separated in the middle of a span by the use of insulated spacers. One such spacer consists of a plastic rod formed in the shape of a square letter "U" with each side being a one turn helix for inter-twining with the line wire. Mid-span transposition brackets will, of course, perform this function incidental to their primary purpose.

Hits resulting from surge voltages appearing across a pair of wires can be reduced by the use of gaseous discharge tubes which are designed to drain both wires to ground simultaneously, regardless of which wire first acquires breakdown potential, thereby minimizing the potential difference between the two line wires. Such hits can be further reduced by the installation of drainage coils in the ground path of the gaseous discharge tubes.

With the increasing sophistication of data and communications systems, impulse noise generated by telephone dial equipment, d-c teleprinter loops, and other interrupted d-c facilities, becomes of greater significance. To eliminate hits from these sources, the recommended practice is to keep the d-c loops in separate cables from the data and carrier or multiplexing circuits. Separation of the cables and the use of shielded cables will provide further isolation.

It is recognized that excessively high levels in a carrier or microwave multiplex system can cause instantaneous crosstalk impulses, which are in effect hits, in data or teleprinter channels. However, even though the system levels may be correctly adjusted, the voice portion of a speech-plus channel is likely to cause this type of interference to associated teleprinter channels. Volume-limiting amplifiers are recommended for use with such voice channels.

An impulse will sometimes appear on a speech-plus teleprinter channel when a PBX operator plugs into the associated voice channel. This type of interference can be eliminated by connecting a semi-conductor diode especially designed and tested for use as a low level regulating device across the voice pair.

REPORT OF
COMMITTEE 2—PRACTICES AND OPERATION

- J. R. DePriest (Chairman), Superintendent Communications and Signals, Seaboard Air Line Railroad.
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L. H. Dyke, Superintendent Communications, Erie-Lackawanna Railroad.
A. E. Emery, Superintendent, Communication Department, Canadian Pacific Railway.
H. E. Froyd, Systems Communication Engineer, Union Pacific Railroad.
A. J. Hendry, Signal Engineer, Northern Pacific Railway.
E. L. Hite, Assistant Superintendent Communications-Traffic, Chicago, Rock Island and Pacific Railroad.
A. L. Jordan, Signal Engineer, Baltimore and Ohio Railroad.
A. J. Kuhr, Sales and Operations Superintendent, Telecommunications Department, Canadian National Railways.
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D. F. Hazen, Assistant Vice President—Operations, The Western Union Telegraph Company.
A. T. Johnston, Consulting Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
R. J. Little, Standards Engineer, General Railway Signal Company.
E. J. Skeppstrom, Assistant Superintendent Equipments and Applications, Teletype Corporation.
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June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.

3. Investigate and report on new signal and communication devices, methods and practices.
4. Study and report on a train hour value.
5. Report on economics of off-track equipment.
6. Cooperate with AREA Committee 18—Electricity.
7. Cooperate with AREA Committee 1—Roadway and Ballast, on reflectorized and luminous roadway signs.
8. Investigate and report on the use of check-in and check-out systems.
9. Study USSR report dealing with research on the possibility of unifying signaling principles and prepare report thereon.
10. Investigate and report on ways and means of interconnecting devices used to detect the presence of heat in journals or car wheels with signal systems and how the equipment is used when not so interconnected.
11. Investigate and report on methods to give warning of approaching trains to employees working on track.
12. Investigate and report on the use of facsimile for railroad communication services.
13. Investigate and report relative to the application of combined automatic business machines and teleprinter equipment for general communication work.
14. Investigate and report on the use of mechanical equipment for signal and communication construction and maintenance service.
15. Prepare requisites for mechanical switch lock, either for inclusion in Manual Part 211—Electric Locks Applied to Hand-Operated Switches for Protection of Main Track Movements, or as separate requisites.
16. Investigate and report on means to minimize loss of record communication, such as teletype and data.

The committee submits for consideration, reports on the following subjects:

2. Insulated Rail Joint Development and Research. AREA Committee 4—Rail has published in their September-October 1961 Bulletin, Volume 63, No. 566, a report on Insulated Rail Joint Development and Research, which is an extended abstract of engineering information developed subsequent to the publication of the original report and is called to the Section's attention because of the continued interest in this subject.

Action Recommended

Acceptance as information.

- 3. Printed Readout, as Exhibit 2-A, page 58.**

Action Recommended

Acceptance as information.

3. Railroad Car "Presence" Detector for Use in Classification Yards, as Exhibit 2-B, page 60.

Action Recommended

Acceptance as information.

- 3. Neon "2nd Train Coming" Sign, as Exhibit 2-C, page 61.**

Action Recommended

Acceptance as information.

- 3. Recording System for Broken Flange and Loose Wheel Detection, as Exhibit 2-D, page 63.**

Action Recommended

Acceptance as information.

- 3. Electronic Solid State Switching Device, as Exhibit 2-E, page 65.**

Action Recommended

Acceptance as information.

- 3. Automatic Broadband Switching System, as Exhibit 2-F, page 67.**

Action Recommended

Acceptance as information.

- 3. High Speed Tape-to-Tape System, as Exhibit 2-G, page 72.**

Action Recommended

Acceptance as information.

- 4. Train Hour Value, as Exhibit 2-H, page 73.**

Action Recommended

Acceptance as information.

- 12. Report on the Use of Facsimile for Railroad Communication Services, as Exhibit 2-I, page 76.**

Action Recommended

Acceptance as information.

- 13. Application of the IBM-1912 Printing Card Punch and Model 28 Teletype to CNR Car Record Service Card-to-Card Operation, as Exhibit 2-J, page 77.**

Action Recommended

Acceptance as information.

- 14. Report on the Use of Mechanical Equipment for Signal and Communication Construction and Maintenance Service, as Exhibit 2-K, page 79.**

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 2—PRACTICES AND OPERATION

Exhibit 2-A

PRINTED READOUT

Printed readout has been developed for use with a hot box detector system. Printed readout presents a permanent record of the passage of a train, including direction, time of day, and location in the train of abnormal heat.

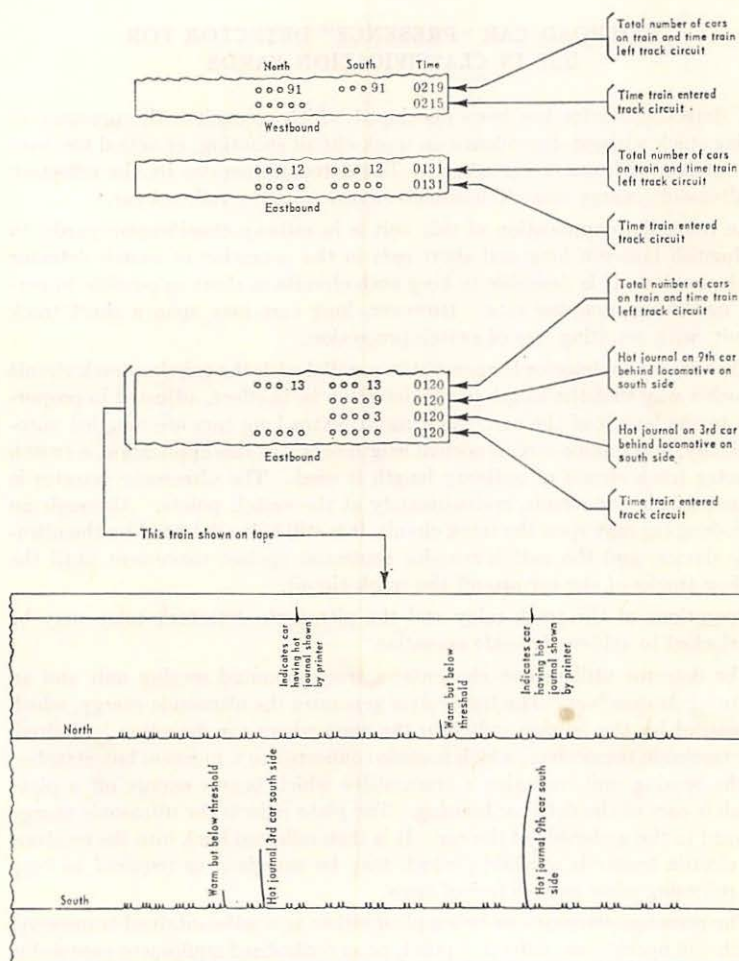
To provide this information, additional equipment other than that used with the basic system is required. A proximity detector and a second wheel detector are installed at the track. Their related circuits count the wheels that are passing over the two wheel detectors. When the same number of wheels passes both detectors, which are mounted on the same rail, the first truck of a vehicle has passed. Counting the same number of wheels for the second truck defines the end of a car. Modular plug-in units are included at the field and office racks for a printed readout system.

At the receiving location a printer counter and analog recorder provide a complete presentation of data. Figure 1 shows the two permanent records for a typical train. The printed record has three columns of figures, car numbers for (1) the north side of the train, (2) the south side of the train and, (3) the time of arrival and departure.

When a train approaches the scanner location, zeros are printed in the north and south columns together with the time. When the direction relay in the field is energized, two rows of zeros and time are printed indicating passage of a train in, e.g., an eastward direction. A train approaching in a westward direction would be registered by a single row of zeros and time. When the train leaves the location, the total number of cars, exclusive of the headend locomotive units, is printed in both columns, together with the leaving time. This record is provided for all trains. When an abnormally hot wheel is detected, the number of the car having that hot wheel is printed in the appropriate column between the entering and leaving notations. If the same car has hot wheels on both sides, the number of the car is printed in both columns.

The conventional analog record is produced for all trains. When a hot box is detected the printer is caused to operate and an event marker makes a mark on the margin of the analog chart indicating the car having the hot box.

Provision is made for a bell and a lamp to indicate when a train approaches detector location. The lamp remains lighted until the train has left the location. A second bell and lamp provide an alarm when the printer is actuated by a hot box. This lamp will remain lighted until a cancel button is pushed, insuring that the operator is alerted to the abnormal condition.



Presentation
Fig. 1

Exhibit 2-B

RAILROAD CAR "PRESENCE" DETECTOR FOR
USE IN CLASSIFICATION YARDS

A detecting device has been developed which recognizes the presence of rolling stock without dependence on track circuit shunting, or actual mechanical contact with car or car wheels. The detector operates by the reflection of ultrasonic energy (inaudible sound waves) from the railroad car.

An immediate application of this unit is in railway classification yards, to distinguish between long and short cars in the operation of switch detector track circuits. It is desirable to keep such circuits as short as possible to permit maximum humping rate. However, long cars may span a short track circuit, with resulting loss of switch protection.

The ultrasonic detector is operated in parallel with the existing track circuit in such a way that the length of the detection is, in effect, adjusted in proportion to the length of the car. As a result, extra long cars are handled automatically, in the same way as normal length cars. In this application, a switch detector track circuit of ordinary length is used. The ultrasonic detector is located within the circuit, approximately at the switch points. Although an extra-long car may span the track circuit, it is still being detected by the ultrasonic device, and the switch remains protected against movement until the trailing trucks of the car are off the track circuit.

Operations of the track relay and the ultrasonic detector's relay may be interlocked to achieve fail-safe operation.

The detector utilizes two elements: a track-mounted sensing unit and an electronic transceiver. The transceiver generates the ultrasonic energy, which is beamed by the sensing unit into the zone where car detection is desired. The trackside transceiver, which is cable connected to a junction box attached to the sensing unit, contains a transmitter which beams energy off a plate which is part of the detector housing. The plate reflects the ultrasonic energy upward to the underside of the car. It is then reflected back into the receiver. An electric heater is available, which may be energized as required to keep the reflecting plate surface free of snow.

The presence detector can be supplied either as a self-contained transceiver which will operate one detection point, or as centralized equipment containing a power supply, common transmitter, and individual receivers for from one to ten detection points.

No special tools or meters are required for installation. Since the track mounted sensing unit does not contain active components, no maintenance on this unit is required. Operation is from 110 volts, 60 cycles.

Exhibit 2-C

NEON "2ND TRAIN COMING" SIGN

Heavily traveled multiple track grade crossings on a western railroad in Portland, Ore., have recently been protected with neon "2ND TRAIN COMING" signs in conjunction with standard flashing light highway grade crossing signals. Object of the new design was to achieve greater intensity of illumination along with greater total area of sign in order to make it more arrestive to operators of motor vehicles.

Typical daily traffic over the two crossings, Balboa Street and Doane Street, are as follows:

	Passenger autos	Tank trucks	All other	Through trains	Switching movements
Balboa Street	600	50	150	50	35
Doane Street	400	100	125	50	100

In view of the many switching movements over these crossings, it was not desirable to place short-arm gates along with the flashing light signals. The alternative was to employ "2ND TRAIN COMING" signs.

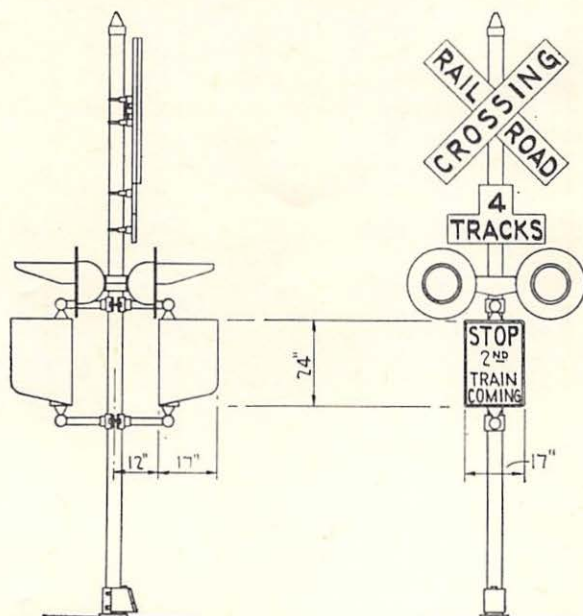


Fig. 1

The new sign, shown in Fig. 1, is an adaptation of a commercial pedestrian warning traffic signal. The face of the sign is approximately 17 inches wide by 24 inches high. Illumination is accomplished by a grid of conventional

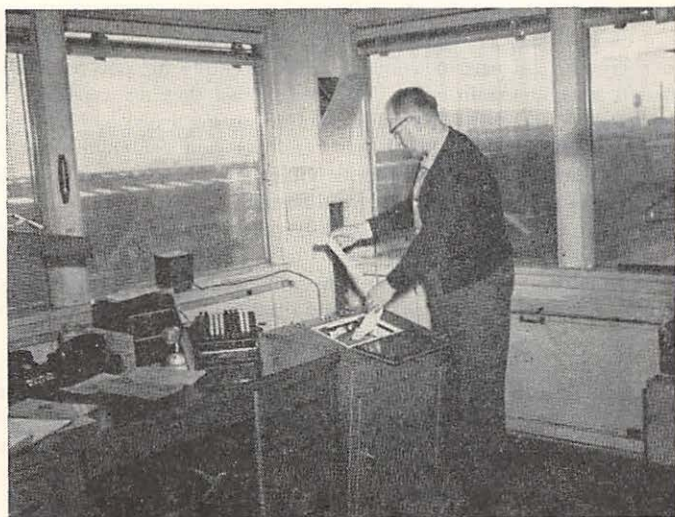
red neon gas tubes placed behind the $\frac{1}{8}$ inch plexiglass sign. The rear surface of the plexiglass sign window is sandblasted and the background is painted black, thereby producing the letters of the sign as sand-blasted translucent areas. Energy for the sign is provided through conventional high-voltage neon sign transformers operated from 110-volt, 60-cycle a-c power source at the crossing. They may be flashed if desired. A conventional d-c to a-c inverter will provide adequate stand-by power.

These signs have been in service over two years with no replacement of neon tubes or sign windows of this kind. Care should be taken to provide adequate operating temperature if signs are to be installed in cold climates.

Exhibit 2-D

RECORDING SYSTEM FOR BROKEN FLANGE AND
LOOSE WHEEL DETECTION

Progress has been made by one railroad in the automation of checking freight car wheels at the easterly entrance to its yard at Spokane, Washington. The system for automatically recording the indications produced by the wheel checking device was developed and installed in 1960. As shown in Fig. 1, information is recorded on paper tape in a small console located in the Yardmaster's office one and one-half miles from the entrance to the yard.



Readout Printer for Wheel Checker Located in Yardmaster's Office
Fig. 1

Defective wheels are detected by a conventional multi-fingered wheel checker over which trains are permitted to move at speeds up to 15 miles per hour entering the yard. The printed information consists of the date, time of day, the number of cars from the head end of the train and, if a defect is being registered, the letter "N" or "S" denoting "north" or "south" side of the train. For example, when a train enters the detector, a zero car count is recorded. As the train proceeds through the wheel checker, defects will subsequently be recorded with the designating "N" or "S" and finally the total number of cars in the train will be recorded as the train departs the wheel checker. A typical recording on the tape would be as follows:

OCT 10	12:47A	0
OCT 10	12:49A	33S
OCT 10	12:54A	148

Counting of cars is accomplished by a 22-foot track circuit which eliminates counting of the engine units and avoids false counts due to the exceptionally

long spaces between the trucks on adjacent trailer-train cars now in operation. The relay in this track circuit picks up once for each car and, in so doing, transmits an electrical impulse to a car count storage device at the Yard Office. This device consists of a three decade rotary stepping switch which steps once for each impulse received. The readout printer is a standard eleven-decade electromagnetic parallel-entry numerical printer. A stepper type digital time clock provides the electrical impulses for time data. When the system calls for data registration, electrical impulses are fed into the readout printer from the digital time clock and the car count storage device. Indicator lights and warning buzzers are also provided in the recorder console so that a registration will not be overlooked in the event attendants are absent when it is initially received.

At the field location of the wheel checker, lunar white indicator lights are mounted back to back on a 23-foot signal mast so they may be observed by the train crew or by yard personnel. The indicators become continuously illuminated when the train enters the detector and they are caused to flash when a defect is detected. The indicators are extinguished and the system is automatically made ready for the next train as soon as a train departs the detector. Car inspectors obtain specific information on the recorded results for each train by telephone from the yardmaster.

Although the car count produced by this system is not necessarily precise, it has proven to be quite satisfactory. Car inspectors are informed of the car identifying number by the yardmaster and they are further aided in locating the car by a yellow marking fluid discharged against the car wheels leaving the detector immediately after a defect has been detected.

Snow is melted from the detector by a tubular electric heater placed at the base of rail under the detector fingers and the marking fluid pump and reservoir are electrically heated to insure operation during severely cold weather. Push buttons are provided both in the field and in the yard office for testing the system.

Exhibit 2-E

ELECTRONIC SOLID STATE SWITCHING DEVICE

During the year 1961, several manufacturers have developed, tested, and placed in service a completely transistorized solid state switching device. These units are compatible with existing telegraph equipment and because of their modular design, can readily be adapted to electronic systems.

Prior to the introduction of electronic devices into the field of printing telegraphy, all switching and control functions obtained through character recognition were accomplished via electro-mechanical methods such as a multi-contact switch.

One switch, originally comprised of 32 contacts, provided a discrete electrical path for each of the 32 Baudot signal codes and was operated by the mechanical code bars positioned via the teleprinter receiving mechanism. The use of this switch, like other electro-mechanical methods for switching and control, required continuous operation of the teleprinter equipment.

Industry in keeping abreast of its rapidly increasing need for printed communications, adopted the use of selective-calling systems. The selective-calling system enables installation of several teleprinter stations on a single half-duplex service. In so doing, expected economies were not fully realized due to increased maintenance cycles which directly affected reliability and life of the equipment. In addition, operating personnel were subjected to noise of teleprinter equipment continuously operating whether or not their equipment was receiving traffic.

Solid state electronic switching devices provide means for switching and controlling of telegraph equipment, and can also be used for control of various components of data processing equipment. Teleprinter equipment, now, remains idle until its assigned characters are recognized by the electronic switching device; then incoming traffic on the teleprinter equipment for which the traffic is intended is permitted to be received. As a result, noise associated with continuous operation of the teleprinter equipment has been eliminated, and operating personnel are aware only of their teleprinter equipment's operating when they are receiving incoming traffic. Substantial economies should be gained due to reduced maintenance cycles and extended life of equipment.

These devices are completely electronic and designed to receive the 7.00 or 7.42-unit Baudot start-stop, 5-channel code at standard speeds of 60, 66, 75, and 100 words per minute. They are adjusted at the factory for any two predetermined speeds with the desired speed obtained by means of strapping. Codes are translated and a discrete electrical path via a transistor for each of the 32 signal codes is provided. Generally, the signal detector is a transistor oscillator and presents a pure resistive circuit to the line. A given amplitude of line current will key the oscillator, causing a mark detection. This oscillator is keyed via signaling "on line" and is isolated from the control logic. The keying of the oscillator forwards bit information into a transistor register, storing each bit until all bits are received. Upon receiving the stop pulse after the fifth bit, the register transfers this information into a diode matrix. The matrix provides an electrical path for each of the 32 Baudot signal codes.

The outputs from the matrix are terminated on a miniature connector. These terminations are then available for strapping into the transistor driver output stage which is terminated on the same miniature connector. These transistors are used for switching upon receipt of the assigned character. Any one of the 32 signal codes can be connected to the output stage by means of strapping.

Since the electronic switching device is completely transistorized it will not require mechanical maintenance because there are no moving parts that could experience wear. Electrical maintenance is confined to the substitution of printed circuit cards.

Exhibit 2-F

AUTOMATIC BROADBAND SWITCHING SYSTEM

General

During the latter half of 1962, Western Union will establish a new and unique service in the field of voice-data communications by inauguration of a switched network of modern and advanced design—The Western Union Broadband Switching System.

This new system, designed for optimum dependability and reliability, will be capable of automatically connecting any two subscribers over one of several varieties of transmission channels, according to the subscribers' communicative needs. The characteristics of these channels have been chosen to accommodate the various forms of analog and digital communications required by business and industry.

The complexities of modern business life are rapidly outstripping the capabilities of existing communications systems. In many cases, it is no longer necessary for the forwarded intelligence to be printed, read, interpreted, and analyzed by human faculties. Indeed it is virtually impossible to obtain efficient and rapid transfer of the increasing volumes of information exchanged today by methods involving conventional manual handling. In many cases, it is now desirable only to have machines reproduce the intelligence as punched holes in paper tape, punched cards, or as signals on magnetic tape, and by means of these media, communicate with other machines at much higher speeds than heretofore have been possible.

The impact of vast increases in the volume of communications has greatly altered circuit requirements. Teleprinter signals are transmitted over either metallic circuits or telegraph-type carrier circuits, at speeds rarely exceeding 100 words per minute, or in the new terminology, 75 bits per second. One individual nominal 4 kc voice-band can easily accommodate a number of such channels. Today, however, modern data-processing machines are capable of operating at speeds of 180, 1200, 2400 bits per second and much higher. These increased transmission rates obviously cannot be accommodated within the same narrow paths as in the past. Wider paths must therefore be made more generally available.

These wide communication paths have existed for some time, although they have not been readily available for general use. Ever since the common-carrier communications industry determined, some decades ago, that wide-band trunk facilities were most efficient for handling heavy traffic, the main communications arteries have been designed to carry large "blocks" of communications channels. These large "blocks" are made up of groups of smaller "blocks" assembled and disassembled by one of several practicable channelizing systems. The end result has been a large number of individual voice-bands or telegraph channels, as the need may be, operable between particular terminals of the channelizing equipment. Because these individual channels have sufficed for most communications requirements until recently, the capabilities of existing switching systems for interconnecting subscribers have been restricted primarily to switching voice-bands or telegraph channels.

Although carrier derived trunk voice-bands are usually the equivalent of

four-wire circuits, they are ordinarily switched on a two-wire basis, and two-wire loops are provided between the central office and the subscriber's installation. This requires the use of hybrid coils, echo suppressors, and companders that have an unfavorable effect upon the transmission of analog and digital data. This deficiency of ordinary telephone switching systems prevents full wide-band duplex operation and thereby reduces the effective transmission speed of certain data handling methods which employ return signals for error correction purposes.

Only recently, have the requirements for data-handling indicated a need for increased use of special bandwidth channels, operating on a two-way basis. In general, these types of channels have been available only on a leased, point-to-point basis. It is evident now that channels suitable for high-speed data handling would be most useful to industry on a switched basis, available when needed. To this end, Western Union's Broadband Switching System has been designed with the capability of switching transmission channels of nominal 0.3 kc, 2 kc, 4 kc, 8 kc, 16 kc and 48 kc bandwidths, all on a four-wire full-duplex or two-way basis. Voice coordination will be available on all channels, except, of course, the 0.3 kc bandwidth.

This new switching system will not only introduce the concept of switching several different bandwidths on demand, but will also have other arrangements especially suited for optimum data-handling efficiency. Existing systems for switching voice-bands, intended primarily for handling speech transmission, lack certain characteristics essential for best quality data handling. For example, sharp clicks and rattles in telephone circuits do little harm to speech reception. These same noises cause serious errors in data operation. Similarly, because the auditory system is insensitive to phase distortion, speech systems are practicable over circuits with delay differences that would cause serious difficulties in data transmission. The system herein described has been designed to minimize "impulse noise" from switching transients and will be equipped with equalizers to correct the delay distortions to the degree necessary for the data service to be performed. In general, therefore, the new system will be capable of providing transmission channels for high-speed data greatly superior to those obtained over existing switched networks.

It is recognized, however, that not all communications will need exceptionally high-speed transmission capabilities. The Broadband Switching System has therefore been designed to accommodate services whose needs are less demanding. Also, the users of very high-speed data devices may utilize the lower speed facilities if they are equipped to do so. Thus the choice of the circuit capabilities remains under the control of the subscriber.

The Broadband Switching System will have the ability to accept communications of widely variant characteristics and carry them to any desired terminus. It will be possible to interconnect, on a direct call-up toll basis, any compatible types of communications or data handling equipment, with voice-coordination service available if desired.

For example, the system will be capable of handling the following forms of analog and digital data communications:

- (a) Voice in coordination with data transmissions.
- (b) Analog data, such as Facsimile, at both low speed and high speed.
- (c) Digital data, such as contained in punched tape, punched cards or as signals from magnetic tape or electronic storage devices.

System Components

Switching Centers

The switching centers, which will be located in Western Union offices, integrate time-proven reliable components with advanced techniques and applications, reflecting the optimum performance attainable in the present state of the art. Particular emphasis has been placed upon eliminating to the greatest degree possible the noise, crosstalk, and distortion elements that would be detrimental to data signals. These centers have also been designed to provide a higher than normal ratio of switching equipment to lines in order to minimize the possibility of "busy" conditions due to equipment congestion.

Facilities

The trunk circuits, which will be obtained principally from Western Union's new transcontinental microwave system, will be four-wire circuits of superior quality. The loops between the switching centers and the subscribers will also generally be four-wire circuits.

Subscriber Components

Modems

As mentioned in the foregoing, business machines and data equipment of many varieties may be interconnected over the Broadband Switching System for the exchange of information. It is necessary, however, that a device be associated with the digital machines to convert their output signals into a form best suited for transmission over the communications facility. These devices are frequently referred to as "Modems," an abbreviation for Modulator-Demodulator. Modems can simultaneously perform both transmitting and receiving functions on duplex facilities.

Western Union has developed a family of such modems. The particular type or types to be used will be determined only after a careful analysis of the subscribers' requirements relating to cost, data volume and available transmission time. These units are compact and have been designed to complement contemporary office furnishings.

Subscriber Voice Set

Each subscriber will be provided with an instrument embodying the most advanced concepts in Data/Voice control. This unit, unique and modern in appearance, is quite simple to operate. The older and slower method of dialing has been replaced by a ten-key push-button array that will transmit the address of the called party to the switching center by means of multi-frequency tone combinations. Although the principal function of the instrument is that of voice communication, it also contains the switching arrangement to enable the subscriber to change his mode of operation, which is indicated by visual signals. Switching to the data mode is accomplished automatically when the handset is rested in a special data position provided for the purpose.

When in the voice mode, the instrument functions as a four-wire, high-quality, voice set. When the handset is placed in the data mode position, the data equipment is automatically connected to the transmission channel. Only when the handsets at both the sending and receiving terminals are in the data position may data transmission commence. As a safeguard in data transmission, a device is contained within each subscriber set to signal the distant attending operator if further voice-coordination between the terminals is de-

sired. This feature will minimize operational delays and improve operating efficiency by allowing a request for voice coordination to be initiated by either end when operating irregularities or unforeseen conditions make it necessary.

Features

Incorporated into this new concept of subscriber-to-subscriber operation are many of the signals, controls, and services that are present in current systems, such as Dial Tone, Busy Tone, Errored Selection and Notification, and Information Service. However, in addition, the following new features have been provided:

Subscriber Numbering Plan

The basic numbering plan is based upon a 7-digit number such as 321-4-567. The first three digits, 321, represent the Western Union switching center which controls the destination point, the fourth digit, 4, indicates the bandwidth of the trunk channel desired, and the last three digits, 567, are those associated with the individual subscriber terminal. This system has been designed to accept 10-digit addresses to provide for possible relaying of calls originating in the Broadband Switching System to other, or foreign, systems.

A special optional numbering plan will enable particular companies utilizing the Broadband System to call among their various offices with 3-digit numbers. This feature will not preclude any station that uses the special 3-digit codes from calling any station in the system by means of the 7-digit codes.

Tone Ringing

The called subscriber will be alerted to an incoming call by a distinctive tone signal, not a ringing bell, and an indication will be returned to the calling party that the called subscriber is receiving this signal.

Rating and Billing

The rate structure for this data-voice service will be based upon the bandwidth called-up for each connection and will comprehend the following factors:

1. A monthly service charge for the subscriber voice set, and the associated subscriber loop connection to the local switching center. This rate will depend upon the capability requested by the subscriber, i.e., the rate for a patron having 48 kc capability will be more than for one having only 3 kc capability.

2. A monthly rental for the modem or other equipment needed to connect the data terminals to the four-wire communications facilities.

3. Charges per call will be determined from detailed information automatically recorded for each completed connection. This information will consist of:

- (a) Calling number.
- (b) Called number.
- (c) Time and date of initiation of call.
- (d) Time and date of completion of call.
- (e) Grade of service requested.
- (f) Special rate data (Day/Night/Weekend/etc.)

Computers will process this information and subsequently prepare the subscribers' monthly statements.

Capacity and Availability

Each switching center, initially, will accommodate 100 subscriber lines and 20 trunks. However, the design is sufficiently flexible so that the ratio of trunks to lines may be readily varied. Provision is made for expansion in ten-line or ten-trunk increments to a maximum of 1000 terminations.

The first several centers are scheduled for delivery in the latter part of 1962 and it is expected that service will be available in 15 cities in the first part of 1963. Tentatively, these cities are: Los Angeles, San Francisco, Chicago, Denver, Kansas City, Dallas, St. Louis, Cincinnati, Cleveland, Detroit, Pittsburgh, New York, Boston, Philadelphia and Washington.

Plans call for 14 additional centers to be in operation by the end of 1963; namely, in Buffalo, Syracuse, Baltimore, Richmond, Atlanta, Birmingham, New Orleans, Greensboro, Oakland, Houston, Seattle, Portland, Milwaukee and Minneapolis.

Summary

Now that the system has been described as to what it consists of, why it is necessary, and what it can do, it would be well to re-emphasize its uniqueness. Some very important points to be remembered are:

1. The system will have the ability to switch automatically bandwidths up to 48 kc on a call-up basis.
2. The system will have superior quality and reliability of transmission, with consequent lower error-rate, assured by:
 - (a) Full four-wire operation, customer-terminal to customer-terminal.
 - (b) Use of specially designed amplifiers and equalizers to minimize signal loss and distortion, whether over short or long haul connections.
 - (c) Switching centers built to transmission, noise and crosstalk requirements unmatched by other commercial systems.
 - (d) High quality, reliable transmission facilities over the most modern microwave radio beam system.
3. The system will permit "full duplex" operation, that is, simultaneous transmission in both directions.
4. The system will provide for faster and more accurate addressing through the use of push-button signaling.
5. The system will enable particular subscribers to contact each other by use of abbreviated 3-digit address codes.

Exhibit 2-G

HIGH SPEED TAPE-TO-TAPE SYSTEM

There is now generally available a new 1000 word per minute tape-to-tape system. The system consists of a transmitter, capable of accepting chadless or fully perforated tapes and a receiver which produces fully perforated tape in response to electrical signals. There are several modulators-demodulators available for operation of this system on regular 3 kc voice channels. Each terminal is packaged in a separate cabinet and requires 15-ampere, 117-volt a-c power source.

The first production units accommodate 5-level tapes only. Subsequent systems will be capable of handling 5, 6, 7 or 8 level tapes. Later models will offer a universal 5 through 8-level system, including error detection and correction.

This tape-to-tape system has been used in test installations since the middle of 1960. Users of these units report that they are quite satisfied with their performance, simplicity of operation, and appearance.

In order to initiate transmission, an operator places the leading edge of a prepunched tape in the reader mounted on the face of the transmitting cabinet. The operator then places telephone call to the receiving terminal and indicates that information is ready for transmission. Following directions from the transmitting end, each operator would put his terminal in the DATA mode by depressing a button. The reader's control handle is then switched to the RUN position and the tape's information is conveyed on the same facility previously utilized for the spoken word. At the end of transmission, the operators depress the TALK button and resume conversation. The system can be operated with automatic circuit selection or with switching systems which would substitute for manual operation.

In operation, information in the tape is read serially by character and converted to a START-STOP, serial-by-bit signal in transistorized control modules. This d-c signal is then forwarded to appropriate modulating equipment for application to suitable voice facilities. The serial signal is received, via demodulating equipment, by the transistorized modules of the receiving terminal. It is there reverted from serial to parallel form and applied to the paper tape punch mounted on the front panel of the receiving cabinet. All of this takes place at a rate in excess of 100 characters each second.

Oct. 1962]

Exhibit 2-H

TRAIN HOUR VALUE

At the 1961 Annual Meeting* the committee submitted a report and presented Table II for the calendar year 1959. A revision of Table II for the calendar year 1960 is herein presented. As shown, total train hour cost (excluding train crew wages) for the year 1960 varied from a minimum of \$24.30 to a maximum of \$89.99 with a composite average of \$48.28 for 70 railroads.

TABLE II

Specified Elements of Train Hour Cost Per Road Freight Train Hour—
Year 1960
(Excluding road freight train crews' wages)

Railroad	Elements of train hour cost (per road freight train hour)			
	Fuel, supplies, enginehouse expense and locomotive repairs	Road freight locomotive depreciation	Payroll taxes on labor applicable to road freight locomotive repairs and enginehouse expense ^a	Total train hour cost (excluding train crew wages)
1	2	3	4	5 = 2 + 3 + 4
Item number**	Items 2 to 8	Item 9	Item 11	Items 2 to 11
NEW ENGLAND REGION:				
1 Bangor & Aroostook.....	\$31.56	\$ 5.28	\$ 0.99	\$37.83
2 Boston & Maine.....	30.07	6.61	1.29	37.97
3 Central Vermont.....	23.52		0.78	24.30
4 Maine Central.....	27.47	5.41	1.11	33.99
5 New York, New Haven & Hartford.....	37.41	7.18	1.32	45.91
6 Rutland.....	19.67	4.87	0.83	25.37
GREAT LAKES REGION:				
7 Ann Arbor.....	34.29	6.52	1.35	42.16
8 Delaware & Hudson.....	48.67	8.06	1.74	58.47
9 Erie-Lackawanna.....	42.44	6.47	1.43	50.34
10 Grand Trunk Western.....	45.89	3.13	1.23	50.25
11 Lehigh & New England.....	30.63	14.15	0.86	45.64
12 Lehigh Valley.....	42.48	7.24	1.32	51.04
13 Monongahela.....	30.38	5.67	1.33	37.38
14 New York Central.....	45.32	5.19	1.58	52.09
15 New York, Chicago & St. Louis.....	32.95	5.13	0.89	38.97
16 Pittsburgh & Lake Erie.....	60.37	0.08	1.44	61.89
17 Wabash.....	45.63	8.17	1.10	54.90
CENTRAL EASTERN REGION:				
18 Baltimore & Ohio.....	39.19	1.85	1.37	42.41
19 Bessemer & Lake Erie.....	62.54	11.59	2.16	76.29
20 Cent. RR of New Jersey (Incl. CRRPa).....	38.81	5.93	1.38	46.12
21 Chicago & Eastern Illinois.....	43.55	5.10	1.13	49.78
22 Detroit, Toledo & Ironton.....	24.33	4.60	0.66	29.59

^a Payroll taxes calculated at rate 10.0 percent to reflect rate of 10.5 percent on monthly compensation not in excess of \$400 per month.

* 1961 Annual Meeting Advance Reports, p. 139.

** See Chapter III—Principles and Economics of Signaling, American Railway Signaling Principles and Practices, p. 20.

TABLE II—Continued

Railroad	Elements of train hour cost (per road freight train hour)			
	Fuel, supplies, enginehouse expense and locomotive repairs	Road freight locomotive depreciation	Payroll taxes on labor applicable to road freight locomotive repairs and enginehouse expense ^a	Total train hour cost (excluding train crew wages)
1	2	3	4	5 = 2 + 3 + 4
Item number**	Items 2 to 8	Item 9	Item 11	Items 2 to 11
CENTRAL EASTERN REGION:—Cont.				
23 Elgin, Joliet & Eastern.....	\$31.26	\$ 1.75	\$ 1.11	\$34.12
24 Illinois Terminal.....	29.20	2.86	0.86	32.92
25 Long Island.....	27.04	2.19	0.99	30.22
26 Monon.....	42.20	5.43	1.51	49.14
27 Pennsylvania.....	41.45	6.03	1.42	48.90
28 Reading.....	34.59	5.99	1.42	42.00
29 Western Maryland.....	46.86	7.28	1.67	55.81
POCAHONTAS REGION:				
30 Chesapeake & Ohio.....	38.86	8.29	1.03	48.18
31 Norfolk & Western (Incl. Virginian).....	35.78	8.11	0.79	44.68
32 Richmond, Fredericksburg & Potomac.....	57.65	8.64	1.77	68.06
SOUTHERN REGION:				
33 Alabama Great Southern.....	45.03	12.31	1.63	58.97
34 Atlantic Coast Line.....	31.91	5.95	1.08	38.94
35 Central of Georgia.....	38.03	5.98	1.22	45.23
36 Cincinnati, New Orleans & Tex. Pac.....	43.09	21.92	1.53	66.54
37 Clinchfield.....	50.95	10.48	1.80	63.23
38 Florida East Coast.....	34.87	7.58	1.11	43.56
39 Gulf, Mobile & Ohio.....	44.43	6.37	1.71	52.51
40 Illinois Central.....	36.80	5.43	0.93	43.16
41 Louisville & Nashville.....	35.87	5.52	1.15	42.54
42 Norfolk Southern.....	30.80	4.01	1.02	35.83
43 Seaboard Air Line.....	38.34	6.93	1.16	46.43
44 Southern.....	28.44	7.22	1.03	36.69
NORTHWESTERN REGION:				
45 Chicago & North Western (Incl. M&STL)....	31.29	4.92	1.04	37.25
46 Chicago Great Western.....	29.12	7.81	0.92	37.85
47 Chicago, Milwaukee, St. Paul & Pacific.....	39.27	4.90	1.17	45.34
48 Duluth, Missabe & Iron Range.....	70.42	17.11	2.46	89.99
49 Great Northern.....	38.61	4.27	1.26	44.14
50 Mpls., St. Paul & Sault Ste. Marie (Incl. Wis. C.).....	33.35	2.78	1.03	37.16
51 Northern Pacific.....	37.92	6.45	1.04	45.41
52 Spokane, Portland & Seattle.....	23.81	4.36	0.86	29.03
CENTRAL WESTERN REGION:				
53 Atchison, Topeka & Santa Fe Sys.....	46.76	5.83	1.47	54.06
54 Chicago, Burlington & Quincy.....	33.94	5.23	0.88	40.05
55 Chicago, Rock Island & Pacific.....	32.07	3.47	0.92	36.46
56 Colorado & Southern.....	30.65	11.00	0.74	42.39
57 Denver & Rio Grande Western.....	46.40	6.87	1.43	54.70

^a Payroll taxes calculated at rate 10.0 percent to reflect rate of 10.5 percent on monthly compensation not in excess of \$400 per month.

** See Chapter III—Principles and Economics of Signaling, American Railway Signaling Principles and Practices, p. 20.

TABLE II—Continued

Railroad	Elements of train hour cost (per road freight train hour)			
	Fuel, supplies, enginehouse expense and locomotive repairs	Road freight locomotive depreciation	Payroll taxes on labor applicable to road freight locomotive repairs and enginehouse expense ^a	Total train hour cost (excluding train crew wages)
1	2	3	4	5 = 2+3+4
Item number**	Items 2 to 8	Item 9	Item 11	Items 2 to 11
CENTRAL WESTERN REGION:—Cont.				
58 Fort Worth & Denver.....	\$29.96	\$ 3.58	\$ 0.79	\$34.33
59 Northwestern Pacific.....	28.70		1.18	29.88
60 Southern Pacific.....	53.86	9.10	2.09	65.05
61 Union Pacific.....	61.59	14.46	1.91	77.96
62 Western Pacific.....	47.25	6.02	1.43	54.70
SOUTHWESTERN REGION:				
63 Kansas City Southern.....	53.72	7.12	1.61	62.45
64 Louisiana & Arkansas.....	36.19	6.33	1.04	43.56
65 Missouri-Kansas-Texas Lines.....	39.75	3.61	1.59	44.95
66 Missouri Pacific.....	39.97	6.52	1.30	47.79
67 Frisco Lines.....	37.86	6.25	1.14	45.25
68 St. Louis Southwestern Lines.....	37.49	5.19	1.12	43.80
69 Texas & New Orleans.....	48.00	2.51	1.60	52.11
70 Texas & Pacific.....	48.89	9.61	1.43	59.93
Composite Average.....	40.69	6.28	1.31	48.28
AVERAGES BY REGIONS:				
New England.....	31.56	6.00	1.20	38.76
Great Lakes.....	43.13	5.70	1.40	50.23
Central Eastern.....	39.98	4.73	1.38	46.09
Pocahontas.....	37.99	8.23	0.95	47.17
Southern.....	35.28	6.60	1.13	43.01
Northwestern.....	35.97	5.18	1.13	42.28
Central Western.....	47.41	7.84	1.54	56.79
Southwestern.....	41.68	5.74	1.34	48.76

^a Payroll taxes calculated at rate 10.0 percent to reflect rate of 10.5 percent on monthly compensation not in excess of \$400 per month.

** See Chapter III—Principles and Economics of Signaling, American Railway Signaling Principles and Practices, p. 20.

Exhibit 2-I

REPORT ON THE USE OF FACSIMILE FOR
RAILROAD COMMUNICATION SERVICES

Trials of facsimile equipment consisting of four transmitters and six receivers were instituted during 1961 at two locations on an eastern railroad. In each instance railroad-owned telephone-grade cable facilities are used between transmitter and receiver. At one location each circuit covers a distance of about 2.5 miles, and at the other location circuits 4.5 and 7.0 miles long are used, the two latter circuits being in a-c electrified territory.

In two cases the installation consists of one transmitter and one receiver connected at all times to the circuit. In one of the other cases there is one receiver with a selecting switch to connect to the transmitting circuit desired as directed by telephone from the transmitting point involved, while in the other instance two transmitters are connected to the same circuit and transmission is only started after telephone conversation between the transmitting points to determine if the line is free for use.

The transmitters are all located at yard offices since the purpose is to provide rapid transmission of information concerning the consists of freight trains leaving the yards. The material transmitted consists primarily of a record of cars arrived and forwarded, which may be hand-written copy produced at the yard office, or copies of teletyped consists of trains received, with insertion or removal of data as the change in consist requires.

The equipment used consists of Datafax facsimile transmitters and receivers which are capable of reproducing the original scanned copy $8\frac{3}{8}$ inches wide on a 400-foot roll of electrolytic paper $9\frac{1}{2}$ inches wide at speeds of $1\frac{1}{8}$ or $3\frac{3}{4}$ inches per minute.

The copy can be viewed and used immediately after reception. In the instant applications the information on the copy is used for cutting teletype tapes for immediate transmission to all points concerned, the copy being held for the freight representatives use for advice to customers. The performance difficulties experienced when the equipment was first installed have been greatly reduced and the systems have now reached a good operating level. Maintenance has been resolved to routine cleaning and inspections, and periodic replacement of parts.

Other than the routine maintenance, the only other periodic attention consists in changing the heater bar assembly on the receiving units, which is done by the receiver personnel at approximately one to two-day intervals depending upon the operating use of the receiver.

Correct voltage is important and regulators were required at several locations to correct changes in voltage.

The equipment is obtained on a rental basis from the manufacturer, who arranges for all necessary maintenance and repairs.

The system provides an operating benefit in that the written material can be prepared by a train conductor enroute, or by anyone at the yard office. No special operating qualifications are needed as the adjustments are now being fixed by the service personnel so that tampering will be eliminated. Poor handwriting or use of unsuitable writing materials may cause lost transmitting time for re-runs or time lost querying the transmitting point by telephone.

The trials are being continued to obtain further experience in operation and performance.

Exhibit 2-J

APPLICATION OF THE IBM-1912 PRINTING CARD PUNCH
AND MODEL 28 TELETYPE TO CNR CAR RECORD SERVICE
CARD-TO-CARD OPERATION

Until May 1961, the CNR Car Record Service program was a card-oriented operation based on the IBM-066 Transceiver. While the card handling capability of this unit is reasonably high (approximately 11 cards per minute), it requires standard voice channel interconnection and lacks flexibility because of the point-to-point method of operation. The necessity of making a number of separate transmissions to advise all on-line offices of the make-up of a freight train and the relatively high cost of voice channels prompted CNR to investigate alternative systems which, while retaining the card-to-card features of the existing system, would meet the following additional requirements:

- (a) The capability of party-line selection and rejection of offices permitting one transmission to cover all points with resulting savings in personnel and transmission time.
- (b) Production of a printed local copy of the train consist for monitor and reference use.
- (c) The use of carrier telegraph channels instead of voice channels.

At the request of CNR, the IBM organization completed development of their 1912 unit early in 1961. This unit is an IBM-026 printing card punch modified by a number of modules and relays to provide facilities for output (send) and input (receive) cables. These cables are connected to an adjacent Model 28 Teletype and its associated "stunt box." The Model 28 Teletype is equipped with a multiple wire distributor mounted on the base at the left rear of the typing unit. This distributor accepts the parallel signal feed from the IBM-1912 unit over the "send" cable and translates these signals into serial form suitable for telegraphic transmission.

For reception of telegraph signals from another office on the circuit, the Model 28 Teletype is equipped with multiple output contacts recently developed by the Teletype Corporation. This set of parts, mounted on the left side of the typing unit adjacent to the code bars, consists of a number of contacts which when operated serially by the code bars provide a parallel output signal acceptable to the IBM-1912 card punch station over the "receive" cable.

The IBM-1912 unit and the Model 28 Teletype with "stunt-box" selector thus constitute a card-to-card operating set which meets the requirements of flexibility and economy listed above. At an operating speed of 75 wpm the equipment will handle approximately eight cards per minute and at 100 wpm it will equal the 11 card per minute performance of the IBM-066 transceiver.

Operation

1. The train consist is produced by preparing an IBM card for each car. Car number, point of origin, contents, destination, etc., are punched into the card.
2. When cards representing a train consist are placed in the 1912 card hopper, they are preceded by a pre-punched header card which contains the office-call selections for the offices required.

3. Each station on the circuit is assigned a two-letter call code, the first letter representing the region and the second the individual office call. This system avoids duplication of office calls at any point on the railway system.

4. The last card of the train consist is followed by a trailer card containing the end of message sequence, Figures "H" and the calls of all offices on the circuit.

5. The keyboards of all Model 28 Teletypes are unlocked at the completion of a card sequence thus permitting use of the circuit for administrative and control message traffic.

The concept herein described is currently in use by CNR in the Maritime Provinces and between Winnipeg and Edmonton. Operation has met all expectations and work is progressing toward completion of system-wide conversion by late 1962 or early 1963.

Exhibit 2-K

**REPORT ON THE USE OF MECHANICAL EQUIPMENT
FOR SIGNAL AND COMMUNICATION CONSTRUCTION
AND MAINTENANCE SERVICE**

An eastern railroad has purchased and placed in operation a truck with a crew cab having a high-reach boom and is using the equipment to perform general pole line work such as digging holes, setting poles, installing crossarms, stringing and removing wire. The crew with the truck generally consists of seven men: one foreman, four linemen, one framer and one helper.

The truck is equipped with a telescopic boom, hydraulically operated outriggers and an hydraulically leveled catwalk, as well as a self-leveling work platform at the end of the boom with removable insulated railing and a vertical center post. Additional equipment includes an auger head, 18-inch auger and full power take-off delivering high volume and pressure oil through telescoping steel tubing. It also has a power reel on the side of the body with remote control of this equipment.

The gross vehicle rating is 37,500 pounds and it has a 6-cylinder engine that develops 120 horsepower at 3600 RPM. The truck has 6-wheel drive, 42-gallon capacity safety type gasoline tank, 20-quart radiator capacity centrifugal water pump cooling system and a 12-volt electrical system including a 12-volt d-c to 110-volt a-c alternator. Receptacles are provided to furnish 110-volt a-c to operate auxiliary power tools as required.

The truck is equipped to operate on the track and can be used to reach over and under the wires to perform work or trim brush.

A truck equipped for this type of work costs approximately \$35,000, varying with the particular requirements as to features and equipment required.

Where the terrain of the railroad line and train traffic is such that this equipment could be used regularly it would decrease the cost of performing work for which it is suited.

REPORT OF
COMMITTEE 3—ELECTRONICS

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R. F. Sparrow, Design Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
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June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.
3. Investigate and report on the use of electronic controls for railway signaling and if deemed desirable recommend basic design principles for electronic controls for railway signaling systems.
4. Report on electronic measuring apparatus applicable to communications and signaling.
5. Investigate and report on principles of detecting the presence of heat in journals or car wheels.
6. Investigate and report on the use of solid state devices for communication or signaling purposes.
10. Investigate and report on the use of electronic or other similar devices that may be used for car identification.
11. Prepare requisites for audio frequency overlay type apparatus.

12. Investigate and report on inductive pick-up loop used in connection with audio-frequency overlay type apparatus.

The committee submits for consideration, reports on the following subjects:

6. Further Introduction to Transients and Their Correlation to Use of Electronic Switches in Lieu of Electromagnetic Relays, as Exhibit 3-A, page 82.

Action Recommended

Acceptance as information.

6. Solid State Indication Storage Device, as Exhibit 3-B, page 86.

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 3—ELECTRONICS

Exhibit 3-A

FURTHER INTRODUCTION TO TRANSIENTS AND THEIR
CORRELATION TO USE OF ELECTRONIC SWITCHES IN
LIEU OF ELECTROMAGNETIC RELAYS

As a sequel to a previous article relative to the broad preliminary aspects of transients, published in the Signal Section 1960 Annual Meeting Advance Notice* as information, an understanding of time constants is essential for an understanding of transient phenomena.

As signal circuits in the past have been concerned with steady state circuits, as mentioned in previous review, modern techniques involve rapid response resulting from characteristics of electronic switches. Of primary importance in design and application are the influences of circuit parameters on components due to sudden changes in applied voltages.

In a particular circuit, after a change from previous state, there is a time interval in which the circuit rapidly adjusts to the change. For a given set of circuit constants, the time interval of adjustment is of uniform duration and usually ends with a steady state condition. The time interval between the first steady state condition to the final steady state condition is known as a "transient interval." During the interval of change, the voltages and currents that exist during the transient interval are referred to as transient voltages and currents. In most literature, steady state voltages and currents are identified by upper case letters such as "E" and "I," while reference to transients is by use of lower case references, as "e" and "i."

For the purpose of simplified explanation, circuit parameters which have an influence on transient phenomena can be reduced to elements of resistance, capacity and inductance.

There is no transient phenomenon associated with the behavior of a resistor, with assumption that there is no inductance or capacitance in the circuit, and the voltage source has an internal resistance of zero. At higher rates of change of voltage source, in practical circuits, such a condition is never fully realized, for even the leads to resistor inherently have an amount of distributed inductance. In initial approach to the resistive circuit it can be anticipated the current in the circuit will assume a steady state instantaneously upon application of a given voltage.

The pure capacitor, without inductance or resistance, would not display unusual transient behavior, other than upon application of a voltage, there would be an instantaneous displacement of electrons from one plate to the other, resulting in an instantaneous flow of current from zero to a maximum and back to a steady state of zero. By the same token, if the capacitor were disconnected from voltage source and short circuited, there would then be another instantaneous current surge, where electrons would equalize the charge on plates.

A pure inductance does not exist as such, since all inductances, by the very nature of their construction, inherently have a component of resistance. In a theoretical case, upon the application of a voltage across an inductance, a current would start to flow. The buildup of flux resulting from a changing current would in turn induce a voltage in opposition to applied voltage, and would

* AAR Signal Section 1959 Proceedings, Vol. LVII, page 144-A.

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tend to retard current build-up; however, in a circuit without resistance the current would build up indefinitely. In practical circuits, the current cannot continue to increase indefinitely, for the resistance of the circuit, no matter how small it might be, will eventually limit the current to the value of E/R .

In practice, every capacitive circuit contains an element of resistance. In the previously mentioned capacitive circuit, the current would have an infinite value in charging a capacitor instantaneously; however, with resistance present, there is a limit to the maximum value of current that might circulate when a voltage is applied. It follows, therefore, that a finite interval of time passes in order to move all the electrons from one side of the capacitor to the other. This period of time is the transient interval.

When an element of resistance is introduced in the charge of a capacitor, for example, it is important to note that the rate of current decay is not uniform. When the switch is first closed on a series circuit containing voltage source, a capacitor and resistor, the current flow is a maximum; however, after an interval of time, a charge is built up on capacitor plates which is opposite in polarity to the impressed voltage. The resultant difference voltage is the force to overcome the resistance of the circuit; therefore, by Ohm's Law, the value of charging current gradually decreases. The pattern of discharge current through a resistor follows a similar pattern in the opposite sense, on short circuit, starting with a maximum current flow which quickly tapers off. It is to be noted that the voltage measured across the resistor varies inversely with the voltage across the capacitor in such a series circuit.

With a combination of a resistance and capacitor in series with fixed values, the magnitude of applied voltage has no effect on the transient interval. If the applied voltage were greater, for example, the current flow would be proportionately greater at every instant; therefore, the time to fully charge the capacitor to the higher voltage would be unchanged. The same concept is true for a reduction in applied voltage; therefore, the time needed to discharge the capacitor to a lower value would remain the same as before.

There is a definite relationship between R and C and the element of time for charge or discharge, which works out to be that resistance in ohms, multiplied by capacitance in farads is equal to time in seconds. The development of this relationship is no coincidence and its source is as follows:

$$R = \frac{E}{I}$$

$$C = \frac{Q}{E}$$

$$R \text{ (ohms)} = \frac{E \text{ (Volts)}}{I \text{ (Amps)}}$$

$$C \text{ (Farads)} = \frac{Q \text{ (Coulombs)}}{E \text{ (Volts)}}$$

Therefore:

$$RC = \frac{\text{Volts}}{\text{Amperes}} \times \frac{\text{Coulombs}}{\text{Volts}} = \frac{\text{Coulombs}}{\text{Amperes}}$$

But by definition:

$$\text{Amperes} = \frac{\text{Coulombs}}{\text{Seconds}}$$

Further by substitution

$$RC = \frac{\text{Coulombs}}{\frac{\text{Coulombs}}{\text{Seconds}}} = \frac{\text{Coulombs}}{\text{Coulombs}} \times \text{Seconds or } RC = \text{Seconds}$$

This relationship for an RC circuit is known as a "Time Constant". A capacitor will become 63 percent charged in one time constant when a voltage is applied, or become 63 percent discharged when short-circuited in one time constant. The charge and discharge patterns follow a very definite relationship which gives rise to a set of curves of "Percent of Maximum Voltage or Current" plotted against units of "Time Constant" which are known as the "Universal Time Constant Chart." In practice, and as noted on a "Universal Time Constant Chart," it takes five intervals of time constant for a capacitor to become $99 + \%$ charged or discharged.

In the case of the series circuit consisting of a voltage source, an inductance and resistance, the same situation exists as for the RC situation. The resistance of an R-L combination limits time of change of current, in that it imposes a maximum value of current, which has a variable effect, as the current through the resistance portion of circuit is a function of the difference voltage between applied voltage and back emf which in turn is a function of rate of change current itself. There is also a time constant relationship for R-L combinations, developed as follows:

$$e_L = L \frac{di}{dt}$$

Instantaneous voltage of inductance = Inductance times rate of change
of current with respect to time

or:

$$\text{Volts} = \text{henries} \times \frac{\text{amperes}}{\text{seconds}}$$

dividing by amperes:

$$\frac{\text{Volts}}{\text{Amperes}} = \frac{\text{henries}}{\text{seconds}}$$

Substituting:

$$\text{Ohms} = \frac{\text{henries}}{\text{seconds}}$$

Rearranged:

$$\text{Seconds} = \frac{\text{henries}}{\text{ohms}}$$

Therefore:

$$t = \frac{L}{R}$$

As is true for the resistor-capacitor case, in an R-L circuit, the transient current is 63 percent from final steady state in one time constant and reaches steady state in five time constants.

The universal time constant chart is equally useful and applies to the R-L case in the same manner as the R-C case, except that the curves become inverted, in that the curve representing the maximum voltage when a voltage is applied to R-C circuit, becomes an indication of maximum current for R-L case.

A further term frequently encountered is the expression "Long Time Constant" and/or "Short Time Constant." The relationship, long or short, has

reference to the actual time elapsed represented by Time Constant of circuit in question as contrasted to the switching rate of frequency of input circuit.

Another interesting relationship between R-C and R-L circuits is that their transient behavior is analogous, in that the voltage wave as formed or measured across the inductor in one case, is obtained across the resistor in the other. By the same token, the voltage obtained across the resistor of the R-L circuit is obtained across the capacitor in the R-C circuit.

So as not to drift too far afield from electronic relays, why R-L and R-C circuits at this time? The fundamentals involved are quite far reaching, in that with R-C and R-L circuits and consideration given to the resultant value of time constant, with respect to signal frequency, it is possible to generate any desired wave shape from a given signal whether it be a square, peaked or other type of output required. Therefore, for any type of input signal, it is simple to develop a square wave, peaked wave, etc., to match the particular input requirements of whatever type of electronic relay might be chosen to perform a particular mission, regardless of characteristics of signal source, or distortions resulting from transmission (within practical limits).

R-C and R-L circuit applications (with due regard for time constants) are frequently design considerations in connection with electronic equipment for coupling electrical signals from one stage to another, usually where it is quite important to pass a desired signal between two stages without any distortion or change whatsoever.

An interesting example of time constants is the form of circuit many detectors use in the separation of two frequencies, as an audio output from the carrier in a standard broadcast receiver. There is also a simple and reliable oscillator known as a "relaxation oscillator," based upon use of a series R-C circuit, which is desirable for the generation of low pulse repetition rates.

A simple substitution of common unit values in relationships such as $TC = RC$ or $TC = L/R$ will indicate that relatively long values of time can be developed with relatively small and simple components. In actual practice, on basis of weight, cost, etc., particularly since effects are converse and substitution is usually possible, the R-C family of circuits is more common than the R-L types.

Exhibit 3-B

SOLID STATE INDICATION STORAGE DEVICE

A solid state device using a silicon controlled rectifier has been developed for use in CTC systems as an indication storage device. Within limits, it may be substituted for the mag-stick relay, presently used for this purpose. It is equivalent to one normally open contact. Operation of a single-stroke bell coincident with lighting an indicator light, for example, requires additional equipment.

A silicon controlled rectifier (SCR) is similar to an ordinary rectifier that has had a gate element added to block it in the forward direction until a small signal is applied to the gate. Application of a gate signal will cause the rectifier to conduct and, like a thyatron, conduction will continue after the gate signal is removed. Removal of the anode supply voltage, or making the anode negative with respect to the cathode, is required to stop conduction.

Figure 1 shows the circuit, the operation of which is as follows:

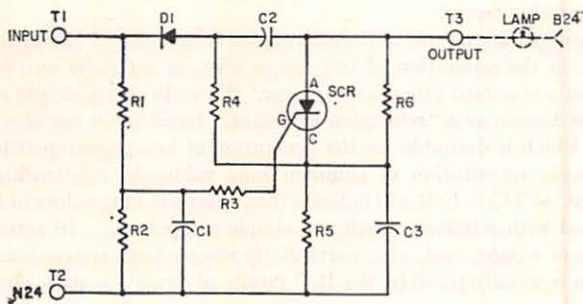


Fig. 1

With the SCR not conducting, a positive cathode bias, determined by voltage divider R6 and R5, ensures that low amplitude gate signals will not cause conduction. Delivery of a positive voltage pulse by the CTC system to input terminal T1 provides sufficient gate current to start conduction and to light the indicator lamp.

To extinguish the lamp, T1 is connected to N24 by the CTC system. This connects the anode to N24 through C2, which is in a discharged condition, and diode D1 in its forward direction. The anode is thus made negative with respect to the cathode (until C2 charges up) and conduction ceases.

Diode D1 prevents polarity reversal on C2 with application of positive gate voltage; C1 filters out short duration transient voltages and prevents false operation of the unit; R3 limits the amount of gate current, and R2 provides a return to N24 for the gate.

This is a volatile storage device. Removal of anode energy will lose a stored indication. Also the lamp supply energy must be direct current.

REPORT OF
COMMITTEE 4—RADIO

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T. M. Evans, Communications Engineer, Chicago and North Western Railway.
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J. Z. Millar, Assistant Vice President, Research and Engineering Department, The Western Union Telegraph Company.
N. Monk, Member, Technical Staff, Bell Telephone Laboratories, Inc.
L. J. O'Connell, Manager Transportation Sales, Graybar Electric Co., Inc.

W. A. Robison, Jr., Manager, Electronic Equipment, Union Switch and Signal Division of Westinghouse Air Brake Company.

W. E. Sutter, Manager of Telecommunications Systems Sales and Services, General Electric Company.

S. Yager, Field Service Manager, Servo Electronic Switch and Signal Company.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
 - 1.1 Collaborate with Mechanical Division with respect to specifications that were joint with the Electrical Section.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.
3. Continue to investigate and report upon the application of ultrahigh frequency or microwave for railroad communications.
4. Keep in touch with any government activities affecting the status of railroads with respect to the application of radio:
 - (a) Cooperate with FCC in assignment of frequencies to individual railroads.
 - (b) Cooperate with FCC in connection with shared use of railroad frequencies by stations in the public safety radio services.
 - (c) Coordination of the assignment of radio frequencies in the United States and Canadian border areas.
5. Assist any railroad to obtain a radio license from the Federal Communications Commission consistent with the policies of the Association of American Railroads.
6. Continue to study and make report to the Section respecting:
 - (a) Use of radio, inductive carrier, or allied communication in connection with railroad operations.
 - (b) Application of radio to harbor craft operation and other mobile services.
7. Keep in touch with activities and developments in connection with other radio services.
 - (a) Cooperate with Operational Fixed Microwave Council.
 - (b) Cooperate with Electronic Industries Association.
8. Cooperate with the Sectional Committee on Radio of the American Standards Association, C-16.
9. Cooperate with the Sectional Committee on Radio-Electrical Coordination of the American Standards Association, C-63.
10. Communication Maintainers' Training Course.
 - C-3 Amplifiers and Oscillators.
 - C-7 New Lesson on Measurements.
12. Investigate and prepare a generalized report on precautions to be observed in servicing transistors and transistorized circuits. This will include

special precautions in the handling of transistors under test and general requirements for test equipment.

13. Prepare requisites for frequency modulation radiotelephone transmitting and receiving equipment and accessories with the objective of simplified installation and maintenance on rolling stock.

The committee submits for consideration, reports on the following subjects:

1. **Revised Minimum Performance Requirements for Long-Haul, High-Capacity Microwave System, 12-23, as Exhibit 4-A, page 91.**

Action Recommended

Acceptance for submission to letter ballot superseding Specification 12-23 in the Communication Manual.

1. **Specifications to be Eliminated from Communication Manual as no longer required:**

12-12—Requirement Specification for Frequency-Modulated Inductive Carrier Telephone Transmitting and Receiving Equipment and Accessories.

12-24—Requirement Specification for Microwave Radio Relay Communication System with Integrated Multiplex and Radio Equipment.

Action Recommended

Acceptance for submission to letter ballot for elimination from the Communication Manual.

4 (a) (b) and (c). **Government Activities Affecting the Status of Railroads with Respect to Radio, as Exhibit 4-B, page 98.**

Action Recommended

Acceptance as information.

5. **Assistance to Railroads.** The objective of activities under this assignment is to simplify as much as possible the process of obtaining authorizations in the Railroad Radio Service. The Committee Officers and the Engineer, Communications and Signals, spend considerable amounts of time each year on matters coming under this assignment. These consist of questions on routine applications filed with FCC for VHF and Microwave authorizations and consideration of difficulties encountered in connection with filings of a non-routine nature. The latter often involve conferences with members of the FCC Staff at Washington, D. C.

Action Recommended

Acceptance as information.

6. **Circulars pertaining to radio matters issued during the year as follows:**

C&S-2 (March 8, 1961)—FCC Rule change permitting transmitter measurements once a year instead of every six months.

C&S-8 (July 25, 1961)—Copy of new Part 626 on Obstruction notice and marking requirements issued by the Federal Aviation Agency.

C&S-9 (July 26, 1961)—Issuance of microwave authorizations on a regular basis.

C&S-12 (September 11, 1961)—Copy of changes in FAA Part 626. (See C&S-8).

C&S-19 (January 15, 1962)—Copy of editorial amendments to Part 16, FCC Rules.

C&S-24 (February 15, 1962)—Interconnection Tariff—Report and Order of FCC Thereon.

C&S-31 (March 22, 1962)—Appointment and Duties—Director of Telecommunications Management.

C&S-33 (April 9, 1962)—FCC—Use of Wide-Band Transmitters under three watts until October 31, 1963.

C&S-34 (April 10, 1962)—Fees for FCC Applications.

Action Recommended

Acceptance as information.

6 (a). Statistics on Railroad Radio Authorizations and Microwave Point-to-Point Systems, are given in Exhibit 4-C, page 100.

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 4—RADIO

Exhibit 4-A**REVISED MINIMUM PERFORMANCE REQUIREMENTS FOR
LONG-HAUL, HIGH-CAPACITY MICROWAVE SYSTEM, 12-23****A—Purpose**

A-1. The purpose of this section is to provide information regarding minimum requirements which should be fulfilled in order to provide satisfactory operation of microwave radio relay systems using frequency modulation of the RF carrier. These minimum requirements for the long-haul system may be interpolated to determine the requirements for a short section which may eventually become a part of the long-haul system.

A-2. This system is to provide a transmission medium for 240 or more voice channels or their equivalent obtained with frequency division single sideband suppressed carrier or other multiplex equipment of a type commercially available and compatible with these baseband specifications.

B—General

B-1. Service Conditions. Unless otherwise specified all performance requirements for equipment described in this specification shall be made on all probable combinations of service conditions specified below:

- (a) Ambient room temperature.....—20 C (–4 F) to 55 C (131 F).
- (b) Ambient humidity.....10 to 95 percent.
- (c) The equipment should meet these requirements at altitudes up to 14,000 feet under normal barometric pressure.
- (d) Duty.....Continuous.
- (e) Primary Power Supply. The radio equipment may be designed to operate either from an a-c source and/or a d-c source.

(1) When operated from a single-phase 50 or 60 cycles per second ± 3 percent a-c source, it shall meet the performance requirements of this specification in the presence of a fluctuation of ± 10 percent about 117 volts, nominal.

(2) When operated on a nominal 24- or 48-volt d-c source, it shall tolerate fluctuations of – 12 percent to + 16 percent. When such a source is used, the positive terminal shall be grounded.

B-2. Normal Test Conditions. Unless otherwise specified the term “normal test conditions” as used in this specification shall be understood to be as given below:

- (a) Ambient room temperature.....22 C (72 F).
- (b) Primary power.....a-c operation 117 volts rms,
60 cps, single phase
d-c operation 24 or 48 volts,
positive terminal grounded
- (c) Power output.....Full rated.
- (d) Mode of operation.....Continuous.

B-3. Frequency Range. This equipment shall be capable of operation within a specified band of frequencies above 900 megacycles which has been assigned for railroad use by the government agency having jurisdiction.

B-4. The radio transmitter and receiver shall be of such design as to permit a maximum number of RF channels to be operated within the band allocated for this class of service by the government agency having jurisdiction.

B-5. Compliance with Government Regulations. This equipment shall be capable of compliance with any applicable rules, regulations or standards of the government agency having jurisdiction which are in effect at the time of delivery of such equipment to the purchaser.

(a) Deviation limiting shall be provided if necessary to comply with government regulations.

(b) The frequency stability of the transmitter shall comply with government regulations.

(c) Parasitic and spurious radiation shall not exceed the value specified by government regulations.

C—System Requirements

C-1. Reliability. Over-all system reliability is dependent upon propagation, equipment reliability, maintenance practices and reliability of primary power with complete standby facilities. System service availability objective considering outages from all causes for a 1000-mile system should be 99.8 percent. Contributing to reliability are: adequate RF power at the antenna, ample radiator size, and conservatively engineered propagation paths.

(a) **Fade Margin.** The fade margin is defined as the additional attenuation that can be placed in any one path of the system during normal propagation before the signal-to-noise margin of the noisiest derived voice channel is reduced to 30 db. The signal-to-noise ratio is defined as the difference between the normal test tone output of a channel in dbm and the residual noise output of the same channel in dbm. This measurement shall be made unweighted between 300 and 3400 cycles.

(b) **Propagation.** In general, the propagation over microwave hops shall be such that a minimum fading margin of at least 40 db is required for non-diversity systems and 30 db is provided for diversity systems. This fading margin is determined by the spacing of repeaters, type and height of antenna system, transmitter power output and receiver sensitivity. RF frequency or space diversity is recommended where propagation conditions are abnormal. The actual fading margin required for a specific installation should be specified by the railroad and guaranteed by the supplier.

Fades of short duration which can be tolerated on a system intended for voice communications result in unsatisfactory operation on a system called upon to carry also distance dialing, VF telegraph, data, or facsimile services.

(c) **System Propagation.** Adequate propagation reliability requires proper path clearances. As a minimum, path clearance should be based upon true earth profiles with 0.6 Fresnel Zone clearance over any obstacle. In coastal land areas, land areas with frequent sub-standard atmospheres, long paths, or paths with high reflections, additional clearance is desirable, such as 0.3 Fresnel Zone clearance based upon two-thirds earth profiles.

Propagation over each path shall be designed to provide over-all system reliability as stated in paragraph C-1.

C-2. Baseband. The baseband is defined as the frequency band available for occupancy by the aggregate of the transmitted signals when first used to modulate a carrier. On frequencies above 960 megacycles the equipment shall provide a baseband as specified in detail herein capable of handling 240 or more voice channels derived with single sideband suppressed carrier or other multiplex equipment of a type commercially available and compatible with these baseband specifications. For heavily loaded trunk routes the baseband width should not be less than 1.5 megacycle.

C-3. Baseband Combiner. A combiner shall not cause interruptions or transients in the baseband signal. Level changes due to automatic combiner action shall not exceed 0.1 db. There shall be no active components common to both RF basebands. The combiner shall be of such design as to permit system operation when either path is disabled because of equipment failure or because either path has been intentionally switched out of service for maintenance. Alarm provision shall be provided in the combiner control to give a minor alarm at all times until the combiner is restored to normal. It shall be possible to bypass both the multiplex baseband and the service channel around the combiner when required for maintenance. The combiner shall be of a fail-safe design. Any combining action, either automatic or manual, in the combiner shall not affect the transmission in the opposite direction.

C-4. Standby Switching. Switching from active to standby equipment shall not cause interruptions or transients in the baseband signal in excess of five milliseconds in length, not including sensing time. It shall not cause a level change in the baseband signal in excess of 0.5 db. Once a switch occurs, the baseband signal shall remain on the second facility until a switch is caused by a failure or is manually restored. Provision shall be made for testing, monitoring and lining-up either "A" or "B" equipments without disrupting the working path.

C-5. Frequency Response. The baseband measured between the input and output terminals of a 1000-mile system shall be flat to within ± 2 db over a range of at least 1 kc to 1.5 mc.

C-6. Level Stability. The stability of the baseband of the system measured between the input and output terminals shall be such that the level of the signal delivered by the receiver will not deviate due to service conditions outlined in paragraph B-1 by more than ± 2 db from the normal output level except during fades in excess of values specified in accordance with paragraph C-1 (a).

C-7. Intermodulation. Non-linearity of any medium used for the transmission of multiple communications channels results in undesired products which may appear in the communications channels as tones, noise or a combination of both. These effects, if of sufficient magnitude, will result in transmission impairment and reduce the effectiveness of the communications channel.

(a) The most effective method of measuring intermodulation distortion is to measure the noise present on one channel of the multiplex system with

all other channels in use. However, this method is not usually practical as a microwave transmission media is seldom initially equipped with its full complement of multiplex channels. As a result, intermodulation performance of microwave systems is usually determined by a technique known as "noise loading." This method is based on the fact that a large complement of working channels produces an aggregate baseband signal which is closely simulated by white, uniformly spread, noise. Commercial, recognized, noise loading measuring equipments are available with which intermodulation performance of microwave equipment may be determined.

(b) Intermodulation measurements shall be made using "Noise Load" technique. Under these conditions the notch to no-notch ratio shall be a minimum of 33.4 db as measured on a 1000-mile system with an RF level 40 db above the level required to produce a 30 db signal to noise ratio in the noisiest 3 kc band of the system; an input level of white noise of an rms power level of 8.8 db above the per channel rms test tone level; and having a bandwidth equal to the bandwidth of a 240 channel multiplexing system.

(c) The techniques involved in measuring intermodulation are beyond the scope of this specification. The supplier of microwave RF equipment should be in a position to guarantee the purchaser that the performance requirements covered in C-7 will be met.

C-8. Noise. The signal to noise ratio including noise from all sources, in the noisiest 3 kc slot within that portion of the baseband to be used for multiplexed communications channels, measured with flat weighting at the equipment output terminals shall be at least 50 db for 1000-mile system with corresponding improvement as system length is reduced. Correspondingly the signal to noise ratio in the baseband from 300 to 3000 cycles for a 1000-mile system shall be at least 34 db.

C-9. The above requirements shall be met with either noise loading representing the systems ultimate number of multiplex channels during the busy hour or shall represent measurements made on actual multiplex channels on a system equipped to its ultimate capacity and measured during the busy hour. The requirements shall be met by each individual r-f channel including individual channels of a diversity pair.

C-10. Power Handling Capacity. The microwave equipment shall be capable of handling a net power level of at least 2 db in excess of the nominal designed level without overload. In other words, the overload point shall be such that the requirements of C-8 shall not be exceeded by more than 2 db with a 2 db increase in total load.

C-11. Input and Output Impedance. The nominal input and output impedance of the baseband equipment shall be 75 ohms unbalanced.

C-12. Input and Output Levels. The radio equipment shall be operable with a minimum per-channel test tone level of -45 dbm input to the radio baseband amplifier and shall deliver at least a -15 dbm receiver output up to 240 channels. These levels shall take into consideration alarms, service channel, pilots, and other tones transmitted simultaneously for supervisory and control purposes.

C-13. Alarms. Alarm detector devices shall be provided on the equipment to indicate equipment failure and excessive signal losses in the r-f trans-

mission path. Separate functional alarms shall be included to indicate transmitter failure, receiver failure or excessive receiver noise.

(a) Contacts shall be provided on the equipment to permit connection to an alarm transmission system. These contacts shall indicate an alarm condition at any transmitter or receiver location and identify the station in trouble.

(b) Input and output facilities shall be provided to permit the transmission of alarm signals over the baseband without degrading the performance below that specified herein. This alarm transmission system will provide facilities for transmission of alarms which may include tower lights, emergency power, unlawful entry, transfer from primary to standby power.

D—Derived Communication Channels

D-1. General. In general, a microwave relay system which meets the performance requirements here set forth provides a broadband transmission medium from which a multiplicity of communication channels may be derived by frequency division multiplexing techniques. To insure compatibility between the multiplex equipment and the radio system and to insure the high quality of performance which microwave relay can provide, the overall expected standards of the communication channels are here delineated. Carrier derived voice bands on radio should meet the following requirements for systems of 1000 miles in length with multiplex terminals at the two ends only.

D-2. Bandwidth. Carrier derived voice channels shall provide a nominal bandwidth of 3.1 kc. The lower cutoff shall not be higher than 300 cycles. The upper cutoff should not be lower than 3400 cycles without signaling. (Cutoff points are here defined as points at which the attenuation is not more than 3 db greater than at 1000 cycles.)

D-3. Voice Frequency Levels. Test tone levels shall be -16 dbm at the input of the modulator and +7 dbm at the output of the demodulator.

D-4. Frequency Response. The frequency response of any voice channel shall not differ from the 1000-cycle equivalent by more than the values shown below:

300 to 400 cps	+0.75 db -2.9 db
400 to 600 cps	+0.75 db -1.5 db
600 to 2400 cps	+0.75 db -0.75 db
2400 to 3000 cps	+0.75 db -1.5 db
3000 to 3400 cps	+0.75 db -2.9 db

A correction factor may be used in applying the above table consisting of the level difference between the response at 800 cycles and the response at 1000 cycles within the channel.

D-5. Level Stability. The output level of a voice channel, when a steady test tone level is applied to the sending side of the distant terminal, shall not vary more than ± 1 db under the service conditions outlined in paragraph B-1 except for fades in excess of that specified in paragraph C-1 (a).

D-6. Wave Form Distortion. Harmonic distortion within a voice channel, as measured by a "Harmonic Distortion Test Set" shall not be in excess of two percent at the nominal test tone level.

D-7. Intermodulation Distortion. If the above limit on harmonic distortion is met, intermodulation distortion detrimental to speech transmission is unlikely to occur in an individual channel. Detection of intermodulation distortion unacceptable to multiple telegraph channel groups is, however, not assured by this measurement. An over-all check of wave form distortion is readily made by using a telegraph channel group. Since it is multiple channel telegraph that feels the effect of wave form distortion most seriously, this approach is a logical one. It is required only to make such tests as will insure that the radio section with its relay stations does not materially increase the aggregate noise within strategically located telegraph channels. Observations are made in a quiescent channel located in the upper half of the band of the noise increase caused by turning all remaining except adjacent channels off and on at the sending end. Under the above conditions the noise shall not increase more than 2.5 db.

D-8. Frequency Displacement. The multiplex system shall not introduce more than one cycle displacement in a frequency introduced at the "send" terminal and observed at the "receive" terminal. While it is true that a one cycle displacement will not adversely affect some types of tone sub-multiplex, others are materially influenced and hence it must be determined what the present and future requirements will warrant. If zero displacement is required it should be specified by the purchaser.

D-9. Signal to Noise Ratio. The signal to noise ratio within any telephone channel on a 1000-mile radio multiplex system without companders and with all other channels loaded with white or random noise equivalent to standard CCIR noise loading should not be less than 50 db measured unweighted. In addition the multiplex on a back-to-back basis shall have a signal to noise ratio of 60 db or better.

D-10. Delay Distortion. Delay distortion, sometimes specified in terms of phase distortion, is of great importance where a voice channel is used for the transmission of serialized high-speed data or facsimile. In simplest language, any significant difference in propagation time at different frequencies is called delay distortion. The magnitude of this difference on an uncorrected carrier channel is ordinarily of the order of a few hundred microseconds. It is greatest near the edges of the band. The equipment shall be so designed that corrective networks can be applied where necessary to hold delay difference in the range from 900 to 2500 cycles to within ± 200 microseconds.

D-11. Channel Impedance. The channel impedance (four-wire), modulator IN and demodulator OUT, of all telephone channels shall be 600 ohms balanced to ground.

D-12. Four-Wire Terminating Equipment. Where channels are to be used on a 2-wire basis, 4-wire terminal equipment shall be provided with 600 ohm impedance on the 2-wire and 4-wire side. The test tone levels to the 2-wire side of the terminal for transmission shall be 0 dbm to -16 dbm at the input of the modulator. The test tone level on the 2-wire terminal on the receive side shall be determined by the operating conditions and will not normally exceed -2 dbm. Facilities shall be provided for adjustment to this level from +4 to -10 dbm.

D-13. Multiplex Terminal Impedance. The input and output impedance of the line or radio side of the multiplex terminal should be capable of meeting a terminating impedance of 75 ohms unbalanced.

D-14. High Frequency Input and Output Levels. The multiplex equipment shall operate with a maximum high frequency input level of -15 dbm per channel and shall provide a minimum high frequency output level of -45 dbm per channel on a 240 channel basis. Adjustable level pads or amplifiers shall be provided to establish proper input and output levels coincident with the number of channels in service, as well as those anticipated in the future to effect proper modulation of the radio frequency baseband of the microwave radio equipment.

D-15. Optional Jackfields. The purchaser, at his option, may specify that jackfields be supplied for inclusion in the equipment for test and patch purposes. The recommended parts are: Single jacks of the 200, 300 and 400 series, or approved equivalent. The basic jackfield shall consist of MOD, DE-MOD, EQUIPMENT IN, EQUIPMENT OUT, 2-WIRE DROP, EQUIPMENT DROP, E AND M LEADS TO MULTIPLEX, E AND M LEADS TO EQUIPMENT, and MONITORING jacks. The field arrangement shall be as specified by the purchaser.

E—Antenna System

E-1. Antennas. Antennas shall be provided as required to meet the specified system transmission performance requirements. Antenna characteristics shall meet all requirements of any applicable rules, regulations or standards of the government body having licensing jurisdiction. Antennas may consist of 2, 4, 6, 8 or 10-foot parabolas or horns either elevated or ground mounted with elevated passive reflectors. In general, where towers are required to meet path clearance requirements, ground mounted antennas with elevated passive reflectors are more economical than elevated antennas. Antenna systems shall be designed so that the atmospheric conditions to which exposed, icing, rain, sleet, etc., shall not adversely affect performance. In areas where icing is experienced the antennas shall be mechanically capable of withstanding the ice load. Antennas may be protected by means of antenna and feed heaters or by means of heated or unheated plastic or fiberglass domes. Where domes are specified, the manufacturer shall state the degree of transmission degradation, if any.

E-2. Passive Repeaters. Reflectors may be used as passive repeaters where system requirements, both technical and economic, indicate their need and suitability.

E-3. Transmission Line. On frequencies from 940 to 2700 mc coaxial cable is normally used. On frequencies above 2700 mc wave guides are normally used.

E-4. Towers.

(a) Tower installations shall in general comply with appropriate EIA specification covering microwave towers.

(b) Tower lighting shall meet the specifications of the government agency having jurisdiction. (FCC Rules Part 17 and FAA Rules Part 626 for U. S.)

Exhibit 4-B

GOVERNMENT ACTIVITIES AFFECTING THE STATUS
OF RAILROADS WITH RESPECT TO RADIO

1. Frequency Assignments

Sixty-two recommendations for modifications in the Frequency Assignment Plan involving 181 assignment changes were filed with the Federal Communications Commission during 1961.

2. Coordination of U.S.-Canadian Radio Frequency Assignments

Subcommittee 4-D continues to function as coordination committee for frequency assignments in the U.S.-Canada border area. During 1961 three recommendations involving eight assignment changes were approved and submitted to FCC.

3. Microwave Systems (FCC Docket 14029)

This docket, issued by the Federal Communications Commission in April 1961, contemplated licensing of microwave systems on a regular basis instead of developmental as heretofore. The AAR filed a supporting statement. The Commission issued a Report and Order in this docket in June 1961 providing that effective July 20, 1961, authorizations for microwave radio stations would be issued for a regular five-year term. Circular No. C&S-9, containing text of the Commission's Order was issued July 26, 1961.

Docket 14179 to provide for assignment of microwave frequencies on a non-interference basis. The AAR filed a statement in this docket indicating that if the "satisfactory showing" of non-interference required of new applicants would be accepted on the basis of "best information available" and not require a detailed engineering showing, the proposed rule would be unobjectionable. This docket is still pending.

4. Antenna Tower Marking (FAA Space Docket 60-WA-159)

Continuing the report on this matter which the committee presented in 1961: The Federal Aviation Agency adopted a new Part 626, effective July 15, 1961, copy of which was furnished in Circular No. C&S-8 dated July 25, 1961. The new part, as issued, eliminated some of the objections filed with the FAA by AAR.

5. Miscellaneous Amendments to FCC Rules

Docket 13953 to amend Part 16, and other parts to provide frequency pairing in the 952-960 mc/s band and make certain frequencies in this band available for omnidirectional operations. The AAR filed a statement in this docket supporting the Commission's proposals. The FCC issued a Report and Order in this docket on July 27, 1961, providing thirty frequency pairs and eight unpaired frequencies to become effective September 1, 1961.

Docket 14042 to amend Parts 10 and 16 to permit routine licensing, until October 31, 1963, of transmitters having less than three watt plate input without compliance with narrow-band technical standards. The AAR filed a supporting statement in this docket. The Commission issued rule changes as proposed to become effective May 1, 1962.

Docket 14311 to change the eligibility section of the Railroad Radio Service Rules and other services to provide for eligibility of a subsidiary corporation. This docket was issued on October 18, 1961, and the AAR filed a supporting statement therein on November 15, 1961. The FCC issued the rule change as proposed to become effective on February 13, 1962.

Docket 14507 to establish fees for FCC licensing and regulatory activities. Filing a statement in this docket was considered. However, the AAR Law Department advised the committee that because of the Association's active support of the user charge principle it was recommended that no statement be filed. The member roads were advised of this in Circular No. C&S-34 dated April 10, 1962.

Exhibit 4-C

RAILROAD RADIO AUTHORIZATIONS

In the interest of conservation of report space the committee is reporting on only the VHF radio authorization totals and on microwave point-to-point systems:

PART I

VHF AUTHORIZATIONS

Classification	May 1961	May 1962
Train, Base	2 228	2 379
Additional xmtrs (TB)	350	352
General, Base	1 087	1 173
Additional xmtrs (GB)	107	113
Train, mobile	25 306	26 416
General, mobile	14 582	14 638
Total xmtrs	43 660	45 071
Total stations	43 203	44 606
Railroad licensees	216	219

PART II

MICROWAVE POINT-TO-POINT SYSTEMS (May 1962)

Railroad and Frequency Band	System	Route Miles
Atchison, Topeka and Santa Fe 6575-6875 mc	(a) Galveston to Beaumont, Tex.	Total 847.25
	(b) Argentine to Topeka, Kans.	
	(c) Los Angeles to Barstow to Bakersfield, Calif.	
	(d) Winslow to Red Mesa, Ariz.	
	(e) Barstow, Calif. to Red Mesa, Ariz.	
	*(f) Amarillo, Texas to Topeka, Kans.	288
Chicago and North Western 6575-6875 mc	*(g) Bill Williams to Wickenburg, Ariz.	507.66
	(a) Chicago, Ill. to West Chicago	92.8
Chicago, Rock Island and Pacific 6575-6875 mc	(a) Goodland to Philipsburg, Kans.	30
Denver and Rio Grande Western 6575-6875 mc	(a) Pueblo to Denver, Colo. to Ogden, Salt Lake City, Utah	135
		700

* Construction permits issued.

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4—Radio

Missouri-Kansas-Texas 6575-6875 mc	(a) Near McAlester, Okla. to Muskogee, Okla.	55.8
New York Central 6575-6875 mc	(a) Indianapolis to Washington Township (Big Four Yard), Ind.	12.2
Pennsylvania 1850-1990 mc	(a) Phoenixville to Reading, Pa.	24
Reading 2110-2200 mc	(a) Manville to Port Reading, N. J.	18.5
Southern Pacific 6575-6875 mc	(a) Black Butte to Dunsmuir, Calif.	17.2
	* (b) Fresno to Los Angeles, Calif.	250
Southern System 6575-6875	(a) Adel and Valdosta, Ga. to Live Oak, Fla.	136
	(b) Washington, D. C. to Atlanta, Ga.	827
	(c) Cincinnati, Ohio to Atlanta, Ga.	954.
	* (d) Knoxville, Tenn. to Chatta- nooga, Tenn.	
	* (e) Chattanooga, Tenn. to Bir- mingham, Ala.	
	* (f) Birmingham, Ala. to Atlanta, Ga.	
Union Pacific 6575-6875 mc	(a) Omaha, Nebr. to Salt Lake City, Utah	1000
	(b) Portland to Hinkle, Ore.	166
	* (c) Salt Lake City, Utah to Los Angeles, Calif. via Las Vegas, Nev.	700

Some of the above 6000 mc systems use frequencies in the 12200-12700 mc band on one or more short spur hops.

Route Miles

Operational.....	4256.95
Under construction.....	2504.46
Total.....	6761.41

* Construction permits issued.

REPORT OF

COMMITTEE 5—INSTRUCTIONS AND SHOP PRACTICE

-
- J. G. Karlet (Chairman), Superintendent Signals and Communications, Norfolk and Western Railway.
J. P. Stevely (Vice-Chairman), Office Engineer, Signal Department, Eastern District, New York Central Railroad.
G. H. Alford, Assistant Signal Engineer, Texas and Pacific Railway.
U. H. Auckerman, District Engineer Signals, Chesapeake and Ohio Railway.
G. D. Booth, Office Engineer, Signal Department, New York, Chicago and St. Louis Railroad.
L. C. Brown, Signal and Electrical Superintendent, Southern Railway.
O. C. French, Signal Engineer, Atchison, Topeka and Santa Fe Railway.
L. G. Hogan, Signal Shop Superintendent, Canadian Pacific Railway.
C. H. Johnson, Office Engineer, St. Louis-San Francisco Railway.
A. C. Krout, Principal Assistant Signal Engineer, Southern Pacific Company.
W. C. McConnell, Supervisor Communications and Signals, Pennsylvania Railroad.
R. F. Miller, Supervisor, Signal Shop, Chicago, Burlington and Quincy Railroad.
C. A. Prickett, Supervisor, Signal Repair Shop, Baltimore and Ohio Railroad.
V. F. Rathje, Assistant Engineer Signals, Chicago, Milwaukee, St. Paul and Pacific Railroad.
E. L. Rogers, Supervisor Signals, Reading Company.
J. F. Stanford, Signal Engineer, Maine Central Railroad.
F. Youngwerth, General Superintendent Communications and Signals, Erie-Lackawanna Railroad.

Consulting Members

- A. T. Johnston, Consulting Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
R. J. Little, Standards Engineer, General Railway Signal Company.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.
3. Investigate and report on shop practices:
 - (a) Assembly of signal components for field installation projects.
 - (b) Repair of signal apparatus.
 - (c) Reclamation of signal and associated material.

4. Investigate and report on noteworthy practices used in repairing signal apparatus.

5. Investigate and report on devices not commercially available, used in repairing signal apparatus.

The committee submits for consideration, report on the following subject:

1. Graphical Symbols. Additional graphical symbols are recommended to form part of Drawing 1667. As these cannot be incorporated in the present drawing, Sheet 2 will be added and is shown as Exhibit 5-A, page 104 of this report. Proposed Sheet 2 shows revisions of symbols for Track Instrument illustrated on present Drawing 1667. If Drawing 1667, Sheet 2, is approved, present Drawing 1667 will be revised to delete the track instrument symbol now shown, and the drawing will be designated as Sheet 1.

Action Recommended

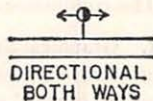
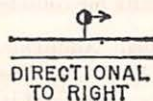
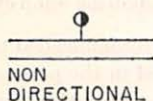
Acceptance for submission to letter ballot superseding Drawing 1667C in the Signal Manual.

Respectfully submitted,

COMMITTEE 5—INSTRUCTIONS AND SHOP PRACTICE

Exhibit 5-A

TRACK INSTRUMENT



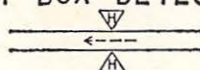
RADAR SPEED MEASURING DEVICE



WEIGHT DIFFERENTIAL DEVICE



HOT BOX DETECTOR

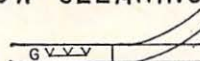


INDICATE BY ARROW IF DIRECTIONAL

AFO (OVERLAY CIRCUIT)



SNOW CLEARING DEVICE



E - ELECTRIC
G - GAS
P - PNEUMATIC
O - OIL OR OTHER

LIGHT COMBINATIONS

LIGHT TRANSMISSION SOURCE



LIGHT RECEIVER



TRAIN IDENTITY



INITIATION COIL



CANCELLATION COIL

GRAPHICAL SYMBOLS

MISCELLANEOUS DEVICES APPLIED TO TRACKS

AAR
SIGNAL
1607D

OCT-1962

REPORT OF
COMMITTEE 6—DESIGNS

- H. L. Hinton (Chairman), Assistant Signal Engineer, New York, Chicago and St. Louis Railroad.
L. A. Sebeczek (Vice-Chairman), Office Engineer, Signal Department, Chicago, Burlington and Quincy Railroad.
R. L. Bush, Assistant Signal Engineer, Chicago and North Western Railway.
B. R. Dellinger, Principal Assistant Signal Engineer, Baltimore and Ohio Railroad.
J. F. Derochie, Traffic Control Engineer, Missouri Pacific Railroad.
R. C. Foster, Assistant to Superintendent Signals System, Atchison, Topeka and Santa Fe Railway.
E. F. Koester, Engineer Signal Design, Chicago, Rock Island and Pacific Railroad.
H. L. Kruke, Assistant Engineer, Chicago, Milwaukee, St. Paul and Pacific Railroad.
W. T. Lewis, Circuit Designer, Canadian National Railways.
J. M. Stanfill, Signal and Electrical Superintendent, Southern Railway.
C. J. R. Taylor, Office Engineer, Communications and Signal Department, Erie-Lackawanna Railroad.
R. E. Testerman, Superintendent Signals, St. Louis-San Francisco Railway.
J. A. Tilton, Designer Signals and Communications, Wabash Railroad.
C. H. Tobin, Superintendent Signals and Communications, Delaware and Hudson Railroad.
P. L. Wheeler, Assistant Signal Engineer, Chesapeake and Ohio Railway System.

Consulting Members

- G. O. Ferm, Commercial Department, General Railway Signal Company.
R. L. Henderson, Transportation Lighting Specialist, General Electric Company.
A. T. Johnston, Consulting Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
R. J. Little, Standards Engineer, General Railway Signal Company.
S. J. Murrow, Senior Application Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.

3. Designs.

(a) Highway crossing signal, flashing light type, 6 ft. and longer, cantilever or bridge span assemblies, utilizing improved construction methods and materials for supporting structures, collaborating with Committee 8.

(b) Perpendicular ladders, platforms, and handrails for use on color light signals.

4. Typical circuits representing current practice for railway signaling.

5. Simplification of sizes and kinds of electric lamps for signal purposes, collaborating with Purchases and Stores Division, AAR.

6. Investigate and report on means and methods for the improvement of incandescent electric lamps used in signaling.

7. Investigate and report on the feasibility of a standard covering size, format, sheet sizes, placing of title blocks, revision blocks, print folds and other format elements in the preparation of signal plans.

8. Collaborate with AREA Committee 5—Track.

9. Investigate and report on the use of drive dowel studs.

The committee submits for consideration, reports on the following subjects:

1. Revised Signal Drawings:

1236E—Two-Way Single-Lamp Signal, page 108.

1488B—"No Right Turn" or "No Left Turn" Signal—Assembly, page 109.

1489G—Highway Crossing Signal—Flashing Light Type with Suspended Lights and Mast Mounted Gate—Assembly, page 110.

1653H—Highway Crossing Signal—Flashing Light Type with Stop on Red Signal Sign—Assembly, page 111.

1686G—Highway Crossing Signal—Flashing Light Type, 6 Ft. and 8 Ft. Cantilever Span—Assembly, page 112.

1688E—Highway Crossing Signal—Flashing Light Type, 10 Ft. and 12 Ft. Cantilever Span—Assembly, page 113.

These drawings have been revised to correct detail references to foundations, and to supersede Drawings 1236D, 1488A, 1489F, 1653G, 1686F and 1688D in the Signal Manual.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

1. Signal Drawings to be Made Obsolete:

1440B—Switch Lamp (Spherical Type).

1443B—Oil Fount (for Spherical Type Lamp—Plan 1440).

1460B—Switch Lamp (Cylindrical Type).

1592A, 1593A, 1594A, 1595A and 1596A—Lamp Details.

Account of obsolescence, it is recommended that these drawings be removed from the Signal Manual.

Action Recommended

Acceptance for submission to letter ballot for removal from the Signal Manual.

1. Signal Drawings to be Eliminated from Manual.

1691E—Highway Crossing Sign—50-Degree Reflector Type—Assembly.

1722A—Highway Crossing Sign—90-Degree Reflector Type—Assembly.

The committee is of the opinion that the highway crossing sign assemblies shown on these drawings are not classified as signal items and therefore recommends, with the concurrence of Committee 8, that they be removed from the Manual. These assemblies are also shown in the AREA Manual and their use, location, etc., are a function of that organization. Removal of these drawings from the Signal Manual will eliminate duplication of work between the AREA and Communication and Signal Section.

Action Recommended

Acceptance for submission to letter ballot for removal from the Signal Manual.

3. Signal Drawing 1296A—Drive Spikes—Details, page 114. As it has been determined that the majority of railroads currently use drive spikes rather than lag screw spikes, this drawing was prepared to supersede Drawing 1381A in the Signal Manual.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

3. (b) Signal Drawing 1435A—Perpendicular Ladders for Ground Masts for Color Light Signals—Assemblies, page 115. This drawing was prepared to cover the demand for ladders used on various types of color light signals. The dimensions and design are coordinated with a view to standardization and eventual elimination of ladders of different design.

Action Recommended

Acceptance for submission to letter ballot for inclusion in the Signal Manual.

4. Typical circuits representing current practice for railway signaling.*

The committee presents herein, following page 116, typical circuit plan AAR Signal 8090A (two sheets). These typical circuit plans are designed to meet current signal problems, but should not be considered as working drawings. It should be understood that they are typical plans, and in applying them to a specific situation, consideration must be given to the type of equipment employed and to local conditions.

Action Recommended

Acceptance as information.

9. Report on the Use of Drive Dowel Studs, Exhibit 6-A, page 116.

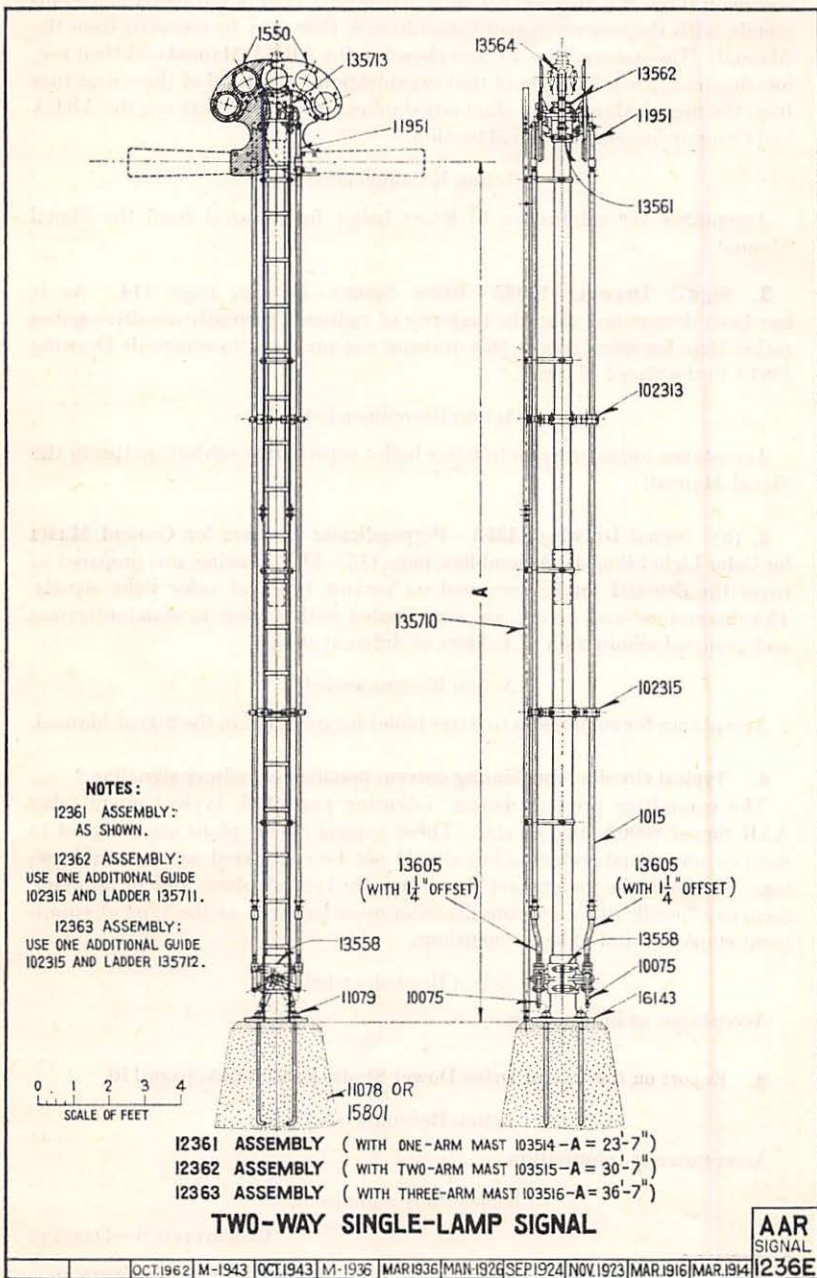
Action Recommended

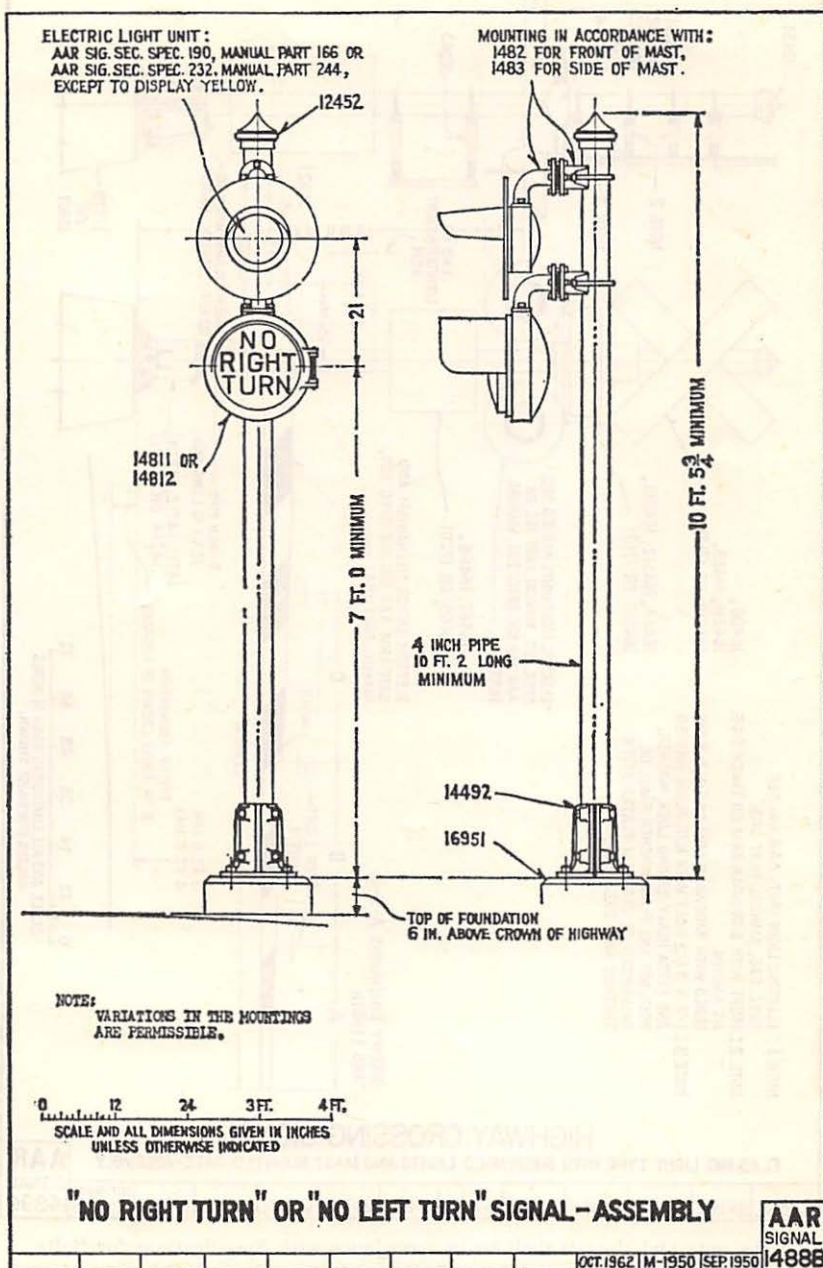
Acceptance as information.

Respectfully submitted,

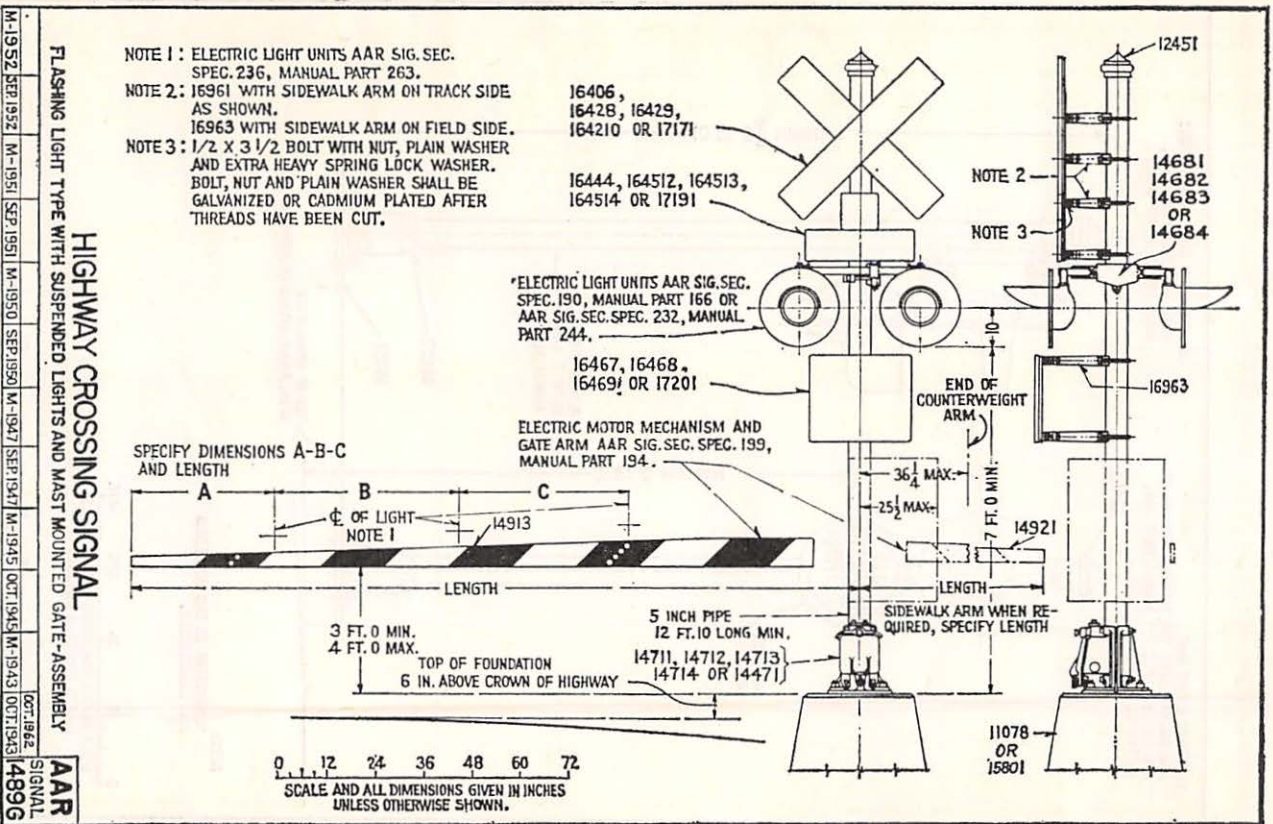
COMMITTEE 6—DESIGNS

* Previous report on this subject appears in AAR Signal Section 1959 Proceedings, Vol. LVII, pp. 148-A and 200-A.

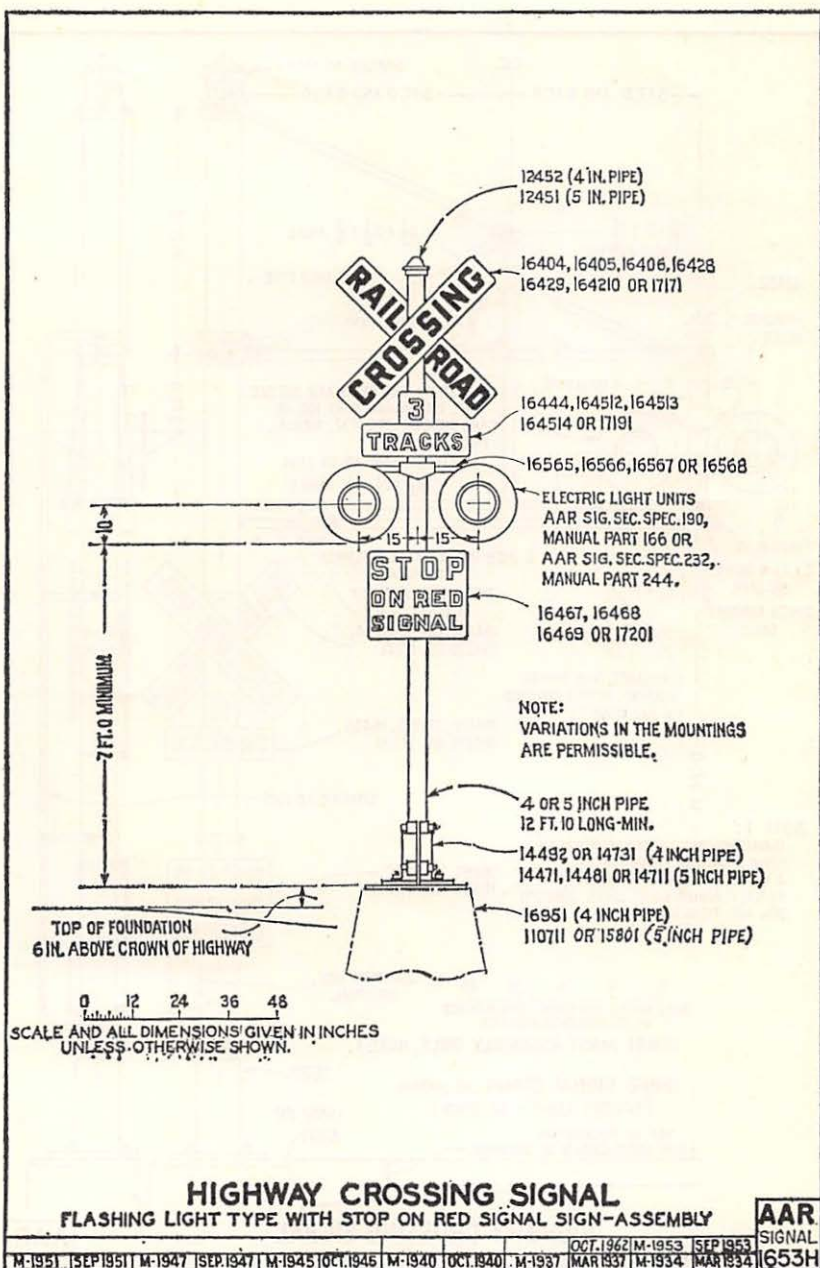




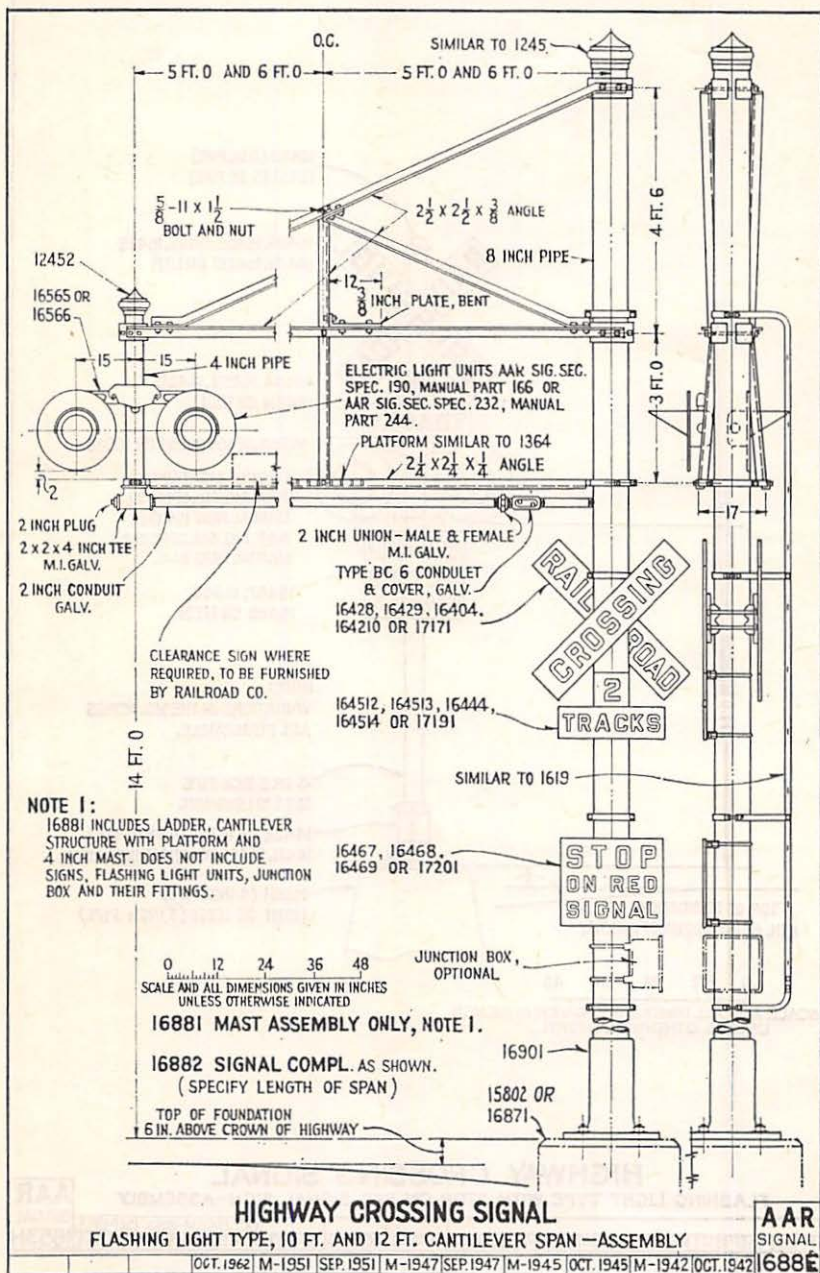
[Oct. 1962]

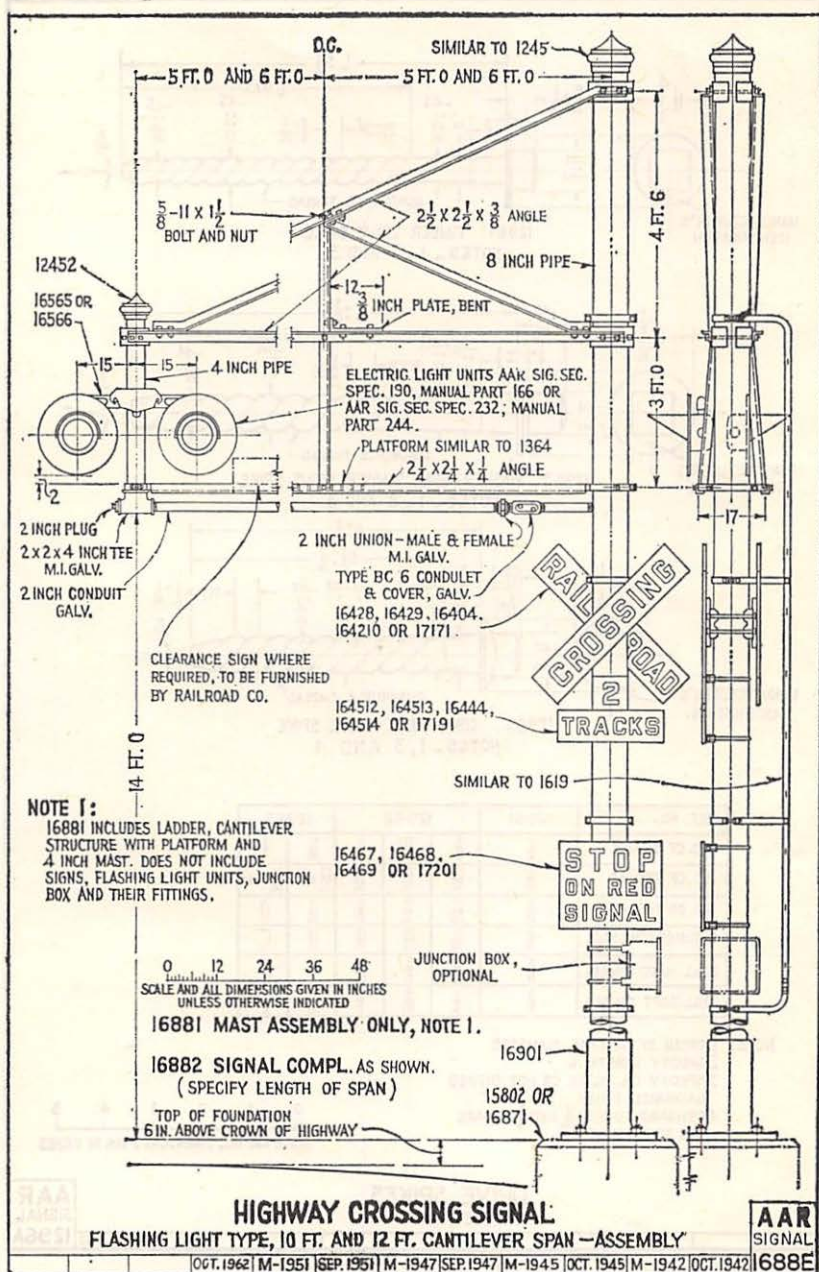


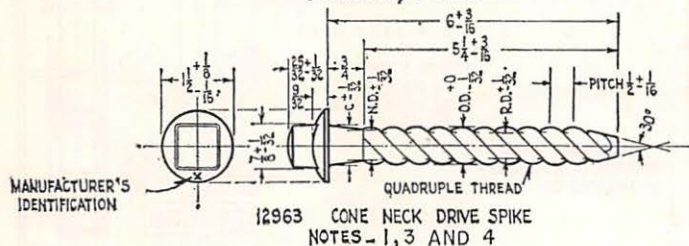
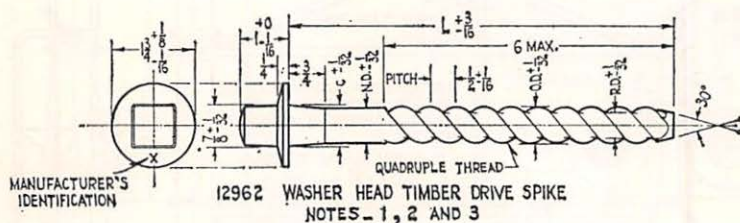
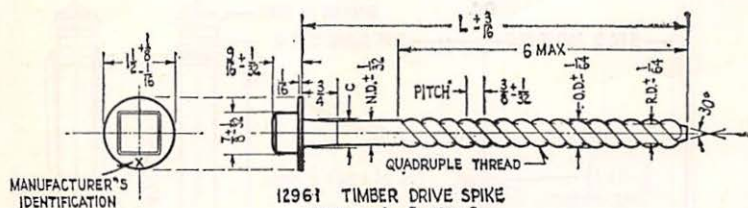
Bolts, nuts and threads shall be in accordance with Specifications for Bolts, Nuts and Threads, Manual Part 17; Spring lock washers shall be of carbon steel (ASA current Specification B27.1 is preferred, where practicable).



Highway crossing signal shall be in accordance with Requisites for Highway Grade Crossing Signals and Devices, Manual Part 148.







REF. NO.	12961	12962	12963
N.D. OF SHANK	1/2	1/2	1/2
O.D. OF THREAD	3/8	3/8	3/8 MAX
R.D. OF THREAD	7/16	7/16	7/16 MAX
C. TOP OF CONE NECK	11/16	11/16	11/16
DRILL HARD TIMBER	1/2	1/2	1/2
DRILL SOFT TIMBER	1/2	1/2	1/2

- NOTES 1. ORDER BY NOMINAL DIAMETER
2. SPECIFY LENGTH L
3. SPECIFY OIL BLACK OR HOT DIPPED
GALVANIZE FINISH
4. DESIGNED TO FIT 1/16 AND 3/4 SQUARE
AND ROUND HOLES

0 1 2 3 4 5
SCALE AND ALL DIMENSIONS GIVEN IN INCHES

DRIVE SPIKES DETAILS

AAR
SIGNAL
1296A

OCT. 1962

Drive spikes shall be in accordance with AREA current Specification for Drive Spikes.

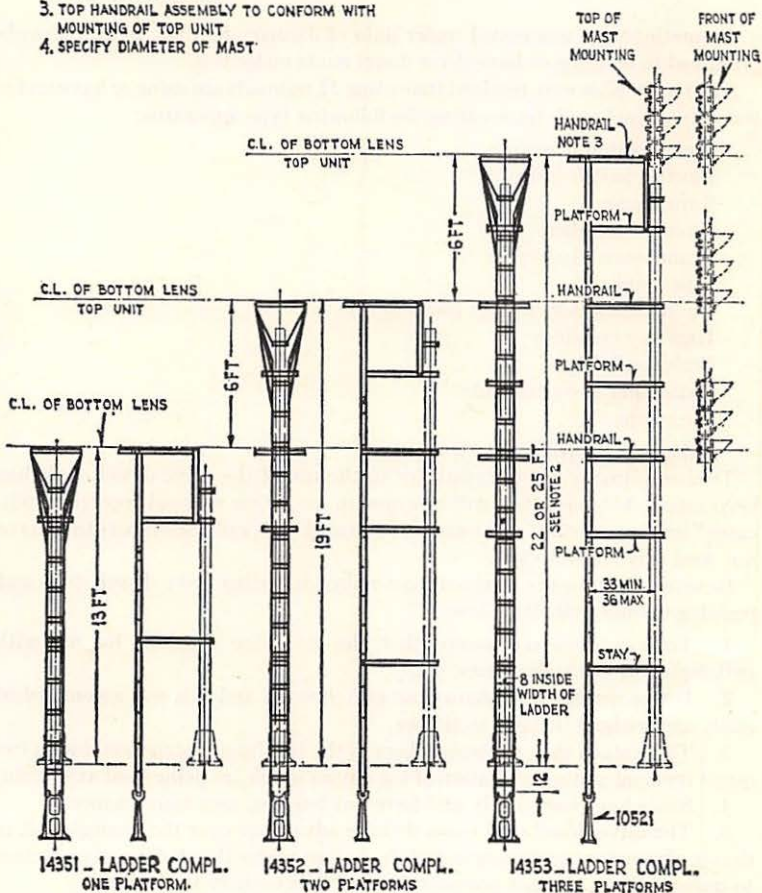
NOTES 1. BOLTS, AS REQUIRED, SHALL BE $\frac{1}{2}$ -13 WITH SQUARE NUTS, AND SHALL BE GALVANIZED OR CADMIUM PLATED

2. WHEN DIMENSION FROM BASE TO C.L. OF BOTTOM LENS IS 10 FT SPECIFY 22 FT FOR 3 UNIT SIGNAL LADDER

3. TOP HANDRAIL ASSEMBLY TO CONFORM WITH MOUNTING OF TOP UNIT

4. SPECIFY DIAMETER OF MAST

0 12 24 36 48 60 72 84 96
SCALE AND ALL DIMENSIONS GIVEN IN INCHES
UNLESS OTHERWISE INDICATED



PERPENDICULAR LADDERS FOR GROUND MASTS

FOR COLOR LIGHT SIGNALS - ASSEMBLIES

AAR
SIGNAL
1435A

OCT. 1962

Bolts, nuts and threads shall be in accordance with Specifications for Bolts, Nuts and Threads, Manual Part 17.

Exhibit 6-A

REPORT ON THE USE OF DRIVE DOWEL STUDS

A questionnaire was issued under date of January 8, 1962, to 22 railroads presumed to be using or have drive dowel studs under test.

Nineteen replies were received indicating 12 railroads are using or have under test drive dowel studs for securing the following type apparatus:

- Power switch machines
- Electric switch locks
- Switch stands
- Circuit controllers
- Train control inductors
- Pipe cranks
- Timber deflectors for hot box scanners
- Highway crossings
- Wales on bridges
- Switch plates on turnouts
- Tie straps

Other light apparatus to track ties

Twelve railroads report experience in the use of the drive dowel studs has been satisfactory and they will continue to use. One railroad reporting indicates "test just started" and no opinion formed. Six railroads report they have not used drive dowel studs.

Resumé of comments received from railroads testing drive dowel studs and replying to questionnaire follows:

1. Tests conclusively proved that the studs are desirable for use with switch stands, controller boxes, etc.
2. It was necessary to change out switch stand and this was accomplished easily and without damage to timber.
3. These studs save the wood fibers in the ties from destruction due to frequent removal and reinstallation of lag screws which are being used at present.
4. Studs have held firmly and have not required any maintenance.
5. The drive dowel stud has a definite advantage over the through bolt in that it eliminates the digging out of the ballast under the tie formerly required to install bolts. Also not necessary to drill hole entirely through tie.
6. Drive spikes are not practical for switch circuit controllers and other equipment which could be broken by hammer; therefore dowel studs are used.

The reports on these tests indicate the practicability of drive dowel studs in signal work as a cost reduction item.

REPORT OF

COMMITTEE 7—INSIDE PLANT

- R. M. Laurenson (Chairman), Superintendent Communications, St. Louis-San Francisco Railway.
- H. N. Wasserman (Vice-Chairman), Superintendent Communications, New York Central System.
- N. L. Atland, Assistant Chief Engineer, Communications, Atlantic Coast Line Railroad.
- E. C. Anderson, Jr., Assistant Communications Engineer, Chesapeake and Ohio Railway.
- T. E. Brewer, Inspector Signals and Communications, Wabash Railroad.
- M. L. Clawson, Communications Engineer, Chicago, Rock Island and Pacific Railroad.
- J. M. Francis, General Supervisor Signals and Communications, Norfolk and Western Railway.
- D. R. Herdine, Assistant Communications Engineer, Chicago, Milwaukee, St. Paul and Pacific Railroad.
- J. W. Hinkle, Assistant Superintendent Communications, Texas and Pacific Railway.
- G. L. Hitt, Communication Equipment Engineer, Illinois Central Railroad.
- E. F. Hutchinson, Superintendent Communications, Chicago, Burlington and Quincy Railroad.
- S. W. Miller, Superintendent Communications, New York, Chicago and St. Louis Railroad.
- N. C. Pace, General Communications Engineer, Southern Railway System.
- H. Rappaport, Engineer Communications, Pennsylvania Railroad.
- A. S. Walker, General Inside Plant Engineer, Communication Department, Canadian Pacific Railway.
- D. R. Weems, Superintendent Communications, Atchison, Topeka and Santa Fe Railway.
- M. R. Williams, Communications Engineer, Louisville and Nashville Railroad.

Consulting Members

- R. C. Ayers, Assistant to Patrons System Engineer, The Western Union Telegraph Company.
- R. A. Clark, Jr., President, Communication Equipment and Engineering Company.
- T. B. Collins, Jr., Manager, Product Engineering, Lenkurt Electric Company.
- E. E. Combs, Vice President-Engineering, Lynch Communications Systems.
- R. F. Davis, Customer Telephone Products Planning Engineer, American Telephone and Telegraph Company.
- H. N. Inwood, Director of Railway and Petroleum Industry Sales, Automatic Electric Sales Corporation.
- L. C. McGee, Sales Manager, R. W. Neill Company.

- L. J. O'Connell, Manager Transportation Sales, Graybar Electric Company, Inc.
R. M. Peters, Assistant to President, Electronic Communication Equipment, Inc.
G. Ramsey, Vice President, Rectifier-Capacitor Division, Fansteel Metallurgical Corporation.
K. J. Terry, Industrial Sales Engineer, General Dynamics/Telecommunications.
I. C. Zager, Railroad Communications Consultant, Teletype Corporation.
-

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.
3. Investigate and report relative to recent developments in power supply equipment.
4. Cooperate with the Sectional Committee on Dry Cells and Batteries of the American Standards Association, C-18.
5. Investigate and report with respect to the installation and maintenance of air cell batteries and other new types of batteries now available.
6. Prepare a report of general informational character covering all types of carrier systems available.
 - (a) Prepare evaluation form to be used in determining major transmission and equipment features of carrier equipment.
 - (b) Investigate and report on performance and design criteria of the various carriers available for use with devices used to determine the presence of heat in journals or car wheels.
7. Investigate and report with respect to proper location of communication equipment in signal consoles.
8. Investigate and report on apparatus available for inter-city and intra-circuit dialing on message telephone circuits.
10. Investigate and report and if deemed necessary prepare specification covering replacement of polar relays in teleprinter equipment with solid-state switching devices.
11. Investigate and report and if deemed necessary prepare specification for replacing the send polar relay in amplitude modulated voice frequency carrier telegraph with solid-state modulator.
12. Prepare specification for nickel-cadmium storage batteries.

The committee submits for consideration, reports on the following subjects:

1. Specification for the Installation and Maintenance of Telephones in Passenger Cars While Standing in Terminals, 2-J-24, revised as per Exhibit 7-A, page 121.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

1. **Specification for Installation and Maintenance of Rectifiers for Supplying D-C Power for Communication Service, 2-J-49.** The following new paragraph D-4(c) on silicon rectifiers to be included:

D-4(c). Silicon. A silicon rectifier diode is a solid state electron device which possesses half-wave rectification characteristics and is normally hermetically sealed into a metal encapsulation with one electrode connected to the case and the other electrode insulated from the case by an insulating medium such as glass or ceramic. Low power devices are normally produced with axial leads and higher power devices are produced with a solder type terminal for one electrode connection and a threaded stud for the other electrode connection. The threaded stud can be either positive or negative polarity. A single silicon rectifier diode is suitable only where a half-wave rectifier is satisfactory. Two or more silicon rectifier diodes can be arranged to provide full-wave rectification. Protective devices are required wherever transients may be encountered to prevent destruction of the diode.

Action Recommended

Acceptance for submission to letter ballot for inclusion in the Communication Manual.

1. **Requirement Specification for Purple Copy and Black Record Ribbons for Use in Telegraph Printers, 2-G-15,** revised as per Exhibit 7-B, page 126.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

1. **Specification for the Installation and Maintenance of Selective Equipment for Remote Control of Printing Telegraph Apparatus, 2-K-28,** is now obsolete and should be eliminated.

Action Recommended

Acceptance for submission to letter ballot for elimination from the Communication Manual.

1. **Requirement Specification for Oiled Perforator Tape, 2-G-16,** revised as per Exhibit 7-C, page 128.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

1. **Specification for Twelve-Ply Cable Sewing Twine, 2-G-18** was reviewed and it is recommended that no change be made in present specification.

However, a review of new methods of tying and fastening wires and cables may be of interest and is submitted as Exhibit 7-D, page 131.

Action Recommended

Acceptance as information.

1. **Specification Covering Wire Chief Equipment in Railroad Offices, 2-J-1.** Proposed additions and revisions are listed in Exhibit 7-E, page 132.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

1. **Instructions and Sample Forms to be Used by Wire Chiefs in Compiling and Recording the Information Called for by the Requirements of Routine Governing Wire Chiefs, 2-J-3.** Drawing C-2215—Symbols for Use on Testboard Wire Chart revised to include symbols for carrier components, and new drawing illustrating use of these symbols to become Sheet 2 of Drawing C-2216—Testboard Chart of Wires and Offices by Lines, are submitted as Exhibit 7-F, page 133.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

1. **A General Description of Printing Telegraph Apparatus and Its Application to Railroad Service, 2-K-23.** Addendum to Appendix 2—Description of Teletype Model 28 Equipment to cover multiple wire output from fixed head distributor and new Appendix 3—Description of Teletype High Speed Tape Reading and Punching Equipment, are submitted in Exhibit 7-G, page 135.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

8. **Dialing on Message Telephone Circuits as Exhibit 7-H, page 139.**

Action Recommended

Acceptance as information.

8. **Apparatus Available for Intercity Dialing, as Exhibit 7-I, page 141.**

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 7—INSIDE PLANT

Exhibit 7-A

REVISED SPECIFICATION FOR INSTALLATION AND MAINTENANCE OF TELEPHONE SERVICE IN RAILROAD CARS, 2-J-24

A—Purpose

A-1. This specification is to prescribe uniform methods and apparatus for installation of telephone circuits and equipment in railroad cars. Because of the difference in design and construction of cars, no attempt has been made to prescribe in detail the mechanical installation. However, careful attention to such details will have an important bearing upon the successful operation of the equipment.

B—Drawings

B-1. Drawings included and referred to:

- C-2259—Typical Application of Car Receptacles
- C-5076—Telephone Type 502-Z2—Schematic
- C-5077—Telephone Type 502-Z2—Wiring Diagram
- C-5078—Conduit and Wiring Diagram

C—General

C-1. This specification covers a standardization of apparatus for use on railroad cars to provide quick connection and easily maintained telephone service. The telephone set is a universal type designed for telephone circuits commonly used on railroads.

C-2. Since many cars move over different railroads and telephone connections are set up by various railroad and commercial telephone company personnel, the first requisite is standardization of equipment since only through standardization will it be possible to easily establish connections to cars at any point on any railroad by means of standard equipment provided at such locations.

D—Apparatus

D-1. **Receptacle.** A two-conductor weatherproof receptacle for mounting on the buffer beam of railroad cars.

(a) Anderson—Type LA 1834, or approved equivalent. To be used for commercial and railroad PAX or common battery PBX circuits using 20-cycle signaling.

(b) Pyle-National—Type CRBB-22, or approved equivalent. To be used for selector or magneto circuits.

D-2. **Plugs.** A two-conductor plug to be used in conjunction with the receptacles described in D-1 for connecting telephone circuits.

(a) Anderson—Type LA 1832, or approved equivalent. For connecting to receptacle described in paragraph D-1(a).

(b) Pyle National—Type SP 16, or approved equivalent. For connecting to receptacle described in paragraph D-1(b).

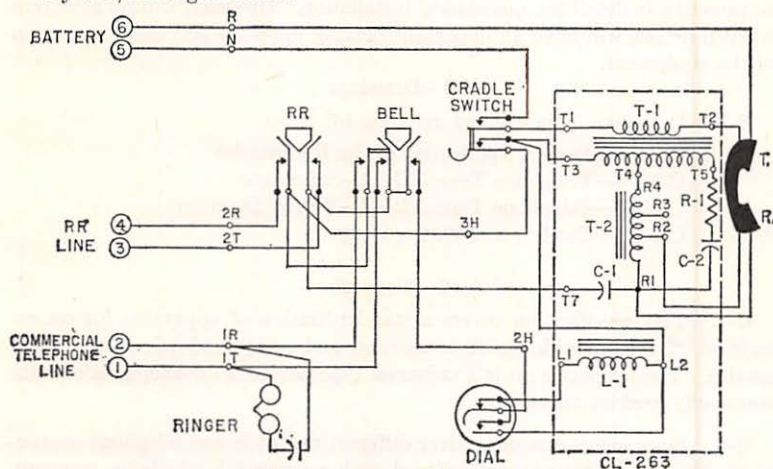
(c) The plugs shall be attached to a flexible cord made up of two stranded No. 14 AWG copper conductors. (Tirex or equivalent) At terminals, the plug and cord may be stored in a weatherproof box or structure in close proximity to the tracks where the cars are parked. The railroad cars shall be equipped with a 50-foot connecting cord with an Anderson plug; also a

100-foot extension cord furnished with Anderson plug and receptacle for use on Commercial telephone circuits.

(d) For service on railroad circuits the car shall also be equipped with a 50-foot connecting cord furnished with a Pyle-National plug on one end and terminal connectors on the other end for attachment to a line pole.

D-3. Telephone. CEE Co.—Type 502-Z2. Drawings C-5076 and C-5077, or equivalent.

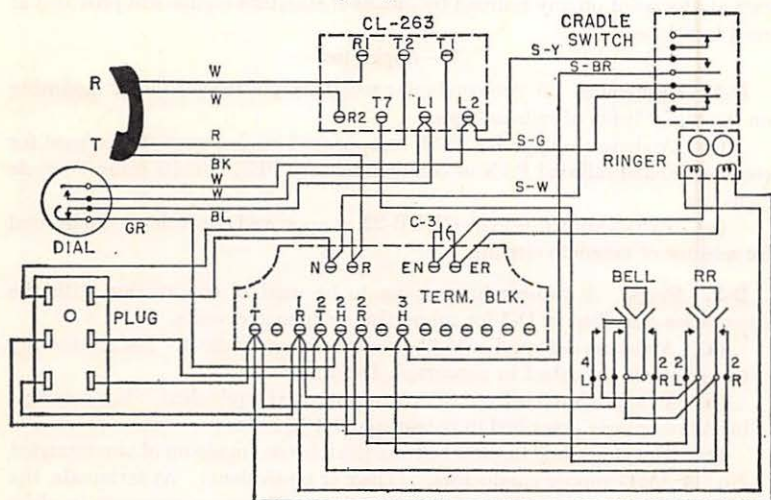
(a) A universal type two-line telephone set for use on dial, common battery and/or magneto lines.



Telephone Type 502-Z2—Schematic

C-5076

June, 1962



Telephone Type 502-Z2—Wiring Diagram

C-5077

June, 1962

E—Signaling Equipment

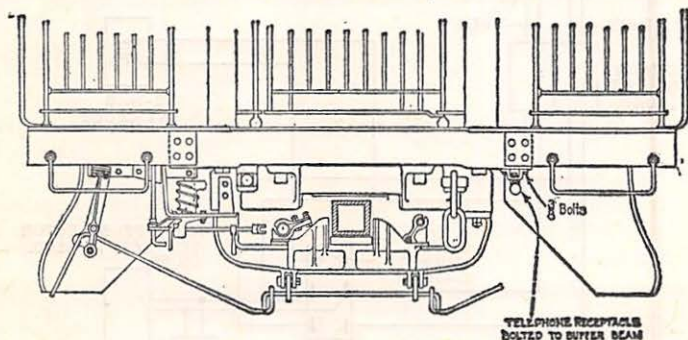
E-1. Extension Bell. An extension bell (W. E. 531AW-3 subscriber set or equivalent) may be permanently connected across the Commercial telephone line.

E-2. Selector. A 160 Type selector may be connected to the railroad line. The selector combination commonly used by many railroads is 13-2, and for the sake of uniformity it is recommended that this be continued.

E-3. Generator. A small generator (Alnico or equivalent), if desired, may be connected across the railroad line.

F—Installation

F-1. Drawing No. C-2259 shows recommended location for mounting weatherproof receptacles on the car. The receptacles shall be mounted to the underside of the buffer beam on the right side of the car on one end and on the left side of the car on the opposite end. Where construction of the buffer beam is such that it cannot be mounted directly on the underside, a suitable bracket shall be provided. Where it is considered desirable, the receptacles may be mounted under the car on each side as near as practicable to the center.



Typical Application of Car Plug Receptacles

C-2259

March, 1934

F-2. Three-quarter inch conduit shall be run along the bottom of the car from the receptacles to a common conduit box, then up through the floor to the telephone receptacle outlet box mounted inside the car.

F-3. A flexible cord (Tirex or its approved equivalent) made up of two stranded No. 14 AWG copper conductors shall be pulled through the conduit and connected to the receptacles. The other end shall be brought into a common conduit box. Conductors from like receptacles shall be individually twisted, soldered, and taped to a common conductor soldered to the telephone receptacle inside the car. Drawing C-5078. Sufficient slack shall be left in the cord so that the receptacles can readily be removed for inspection.

F-4. The receptacle inside the car shall be installed in close proximity to the telephone location. Care shall be taken to locate the receptacle so that when the plug is inserted, it is not in a position where it will be knocked by the knees of the person sitting at the desk or table.

F-5. The extension bell, selector case and generator shall be installed nearby, readily accessible for proper maintenance.

G—Maintenance

G-1. Test batteries. (See Specification 2-K-3, Section E.)

G-2. Test telephone transmission and reception. (See Specification 2-J-7, Section L.)

G-3. Check for loose wires, damaged cords, and dirty contacts.

G-4. Check receptacle cord and telephone connections.

G-5. Check car receptacles. Inspect to see that the assembly is tight, and connecting prongs are clean and free from dirt and corrosion.

G-6. Check plug and attached cord. Particular attention shall be given to the condition of the flexible connecting cord to be sure the insulation is good and that the cord is not otherwise damaged or in bad condition.

H—Parts List

Unit or Approved Equivalent	Type Reference
Telephone—Complete.....	502-Z2
Handset.....	P65C
Transmitter Capsule.....	PP66521
Receiver Capsule.....	PP75547
Cord, 4-Conductor.....	P7-207
Dial.....	P19-G
Cradle Switch.....	P75300
Ringer.....	P130-3A
Housing Assembly.....	P75-401
Subset, L-1, T-1, T-2, C-1-2, R-1.....	CL-263
T-1, Hybrid Transformer.....	CL-260
T-2, Auto Transformer.....	CL-261
L-1, Choke.....	CL-262
R-1, 620 ohm 1W Carbon.....	
C-1-2, 0.5 mfd 200 DCWV.....	P8282
Plug (P-1) Jones.....	P406-CCE
Receptacle (CS-1) Jones.....	S406-AB
Capacitor (C-3) 0.5 mfd 400 DCWV.....	P84CM
Plate, Receptacle (S-1) Mounting.....	P-7-208-6
Generator, Alnico—Small Box.....	A556-S1
Bell, Extension.....	531AW-3
Selector.....	60 AP
Selector Set.....	162-T - 162-S
Conduit Box, for Mounting Receptacle.....	Any
Receptacle, for Car Mounting.....	LA-1834
Receptacle, for Extension Cord.....	LA-1829
Plug, for Cord.....	LA-1832
Receptacle, for Car Mounting.....	CRBB-22
Receptacle, for Extension Cord.....	CRB-22
Plug, for Cord.....	SP-16

Exhibit 7-B

REVISED REQUIREMENT SPECIFICATION FOR
PURPLE COPY AND BLACK RECORD RIBBONS
FOR USE IN TELEGRAPH PRINTERS, 2-G-15

A—Purpose

A-1. This specification covers the requirements for purple copy and black record ribbons for use in teleprinters.

B—Drawings

B-1. None included.

C—General

C-1. Either purple copy or black record ribbons shall be furnished as specified in the invitation for bids.

D—Material and Dimensions

D-1. The material and dimensions of purple copy and black record ribbons are the same.

D-2. **Fabric.** The cloth shall be a first grade cotton fabric evenly and closely woven from threads of uniform size, and free from imperfections of manufacture which affect the appearance or serviceability of the ribbons.

D-3. **Thread Count.** There shall be not less than 133 warp or 133 filling threads per inch, but the sum of the warp and filling threads shall be not less than 270 and the difference shall not exceed 10 per inch.

D-4. **Width.** The width of the ribbon shall be not more than 0.51 in. nor less than 0.48 in.

D-5. **Length.** The length of the ribbon shall be 12 yards unless otherwise specified.

D-6. **Thickness.** The thickness of the ribbon after inking shall be not more than 0.0058 in., nor less than 0.005 in., measured with a micrometer having a measuring surface of $\frac{3}{8}$ in. diameter.

D-7. **Edges.** The edges of the ribbon shall be straight, smooth and properly treated to prevent fraying.

D-8. **Inking.** All ribbons shall be evenly inked and non-type-filling. (See paragraph F-4.) The ink shall be first grade, free from any constituents which would in any way harm the type or cause corrosion of any metal part with which it may come in contact. The dyes used shall be such as to insure permanence of color during the life of the ribbon. Inking shall be to the degree commonly known as medium.

D-9. **Hooks and Eyelets.** The ribbons shall be furnished with hooks and eyelets. The hooks shall be located approximately $\frac{1}{2}$ in. from the ribbon ends, with the reversing eyelets located between 4 and 6 in. from the hooks.

E—Spools and Winding

E-1. The ribbons shall be wound on spools of metal construction, and of a type that will operate properly in teleprinters.

E-2. The ribbons shall be wound on the spools in such a manner that there will be no fold, wrinkle or tears in the ribbon when unwound.

E-3. For purple copy ribbons inked on one side only, it shall be specified whether the inked side shall appear on the inner surface or outer surface as the ribbon comes off the spool, e.g., Model 15, outer surface; Model 28, inner surface.

F—Performance

F-1. Character of Writing. The first record obtained from a new ribbon shall be clean cut.

F-2. Copy Ribbons. The first copy obtained from the first record of a new copy ribbon and the record itself shall not show any evidence of excessive running or blurring nor have a smudgy appearance. Copies of the records shall be obtained by means of a duplicating machine or by means of wet tissue run through a roller press.

F-3. Wear-Down. The inked ribbons shall be capable of withstanding a wear-down test of 4500 characters per inch of ribbon on a teleprinter. The ribbons will be considered as meeting this requirement if, at the end of the test, no thread of the fabric is broken or severed.

F-4. Type Filling. The letter "e" shall be thoroughly cleaned and 800 impressions made with it, with normal travel of the ribbon. There shall be no evidence of filling of the type.

G—Packing

G-1. Each ribbon shall be suitably wrapped, and shall be enclosed in an individual container, marked with the kind and color of the ribbon, the degree of inking and the date on which the ribbon was manufactured.

H—Warranty

H-1. The seller/contractor shall warrant that the material furnished under this specification shall be free from defects in design, material and workmanship. The seller's/contractor's obligation under this warranty shall not apply to any material which has been subject to misuse, negligence or accident after acceptance.

H-2. The seller/contractor shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents, or for patent royalties involved, in consequence of the purchase or use of the material covered hereby.

Exhibit 7-C

REVISED REQUIREMENT SPECIFICATION FOR
OILED PERFORATOR TAPE, 2-G-16

A—Purpose

A-1. This specification covers requirements for $1\frac{1}{16}$ in. oiled perforator tape for use on standard tape perforating equipment.

B—Drawings and Specifications

B-1. Drawings. None included.

B-2. Specifications referred to are current issues of:
Federal Specification UU-T-120—Tape, Teletypewriter, Perforator.
Federal Specification UU-P-31—Paper, General Specifications and Methods of Testing.

C—General

C-1. **Composition.** The paper stock shall be composed of 100 percent bleached chemical wood pulp impregnated with a light grade paraffin base lubricating oil which is free from acids, as nearly odorless as commercially practicable, and in accordance with the current edition of Federal Specification UU-T-120.

C-2. **Workmanship.** The tape shall be suitable for the perforation, recording and transmission of teletypewriter messages. The oiled tape shall have a hard, smooth, dull finish and shall be as opaque and as free from unbeaten fibers, fluff, paper dust, grit, dirt spots, wrinkles, folds and edge tears as the best manufacturing practice will permit. It shall be uniform in thickness and width. The roll shall have clean-cut edges, without nicks, and shall be one continuous length without splices.

C-3. **Conditioning.** For the tests of physical requirements, the samples shall be removed from the roll and conditioned for at least 16 hours in an atmosphere maintained at 50 ± 2 percent relative humidity and $23 \text{ C} \pm 2 \text{ C}$ ($73 \text{ F} \pm 3.5 \text{ F}$), in accordance with the current edition of Federal Specification UU-P-31—Method 102—Atmospheric Conditions.

D—Requirements

D-1. The paper stock shall meet the following general requirements:

Weight per ream (500 sheets 17 in. by 22 in.) lbs.....	18 to 20
Thickness, in.....	0.0038 to 0.0043
Width, in.....	0.685 + 0.005 - 0.002
Oil Content, by weight.....	12% Min., 22% Max.
Tensile Breaking Strength, dry	
Kilograms per 15 MM of Width	
Machine Direction.....	6.0 KG
Cross Direction.....	4.0 KG
Folding Endurance, Schopper.....	90 Dbl folds
Ash Content.....	1.00% Max.
Grit Content.....	0.03% Max.

E—Test Procedures

E-1. Test requirements for paper stock shall be made in accordance with methods described in detail in the current editions of Federal Specifications UU-P-31 and UU-T-120. Tests for requirements listed in paragraphs E-2 to E-9, inclusive, are given as information and are a summary of provisions described in Federal Specifications UU-P-31, issue b, and UU-T-120, issue b.

E-2. Basis Weight. Using ten specimens each 100 square inches in area (tolerance 0.25 percent), weigh with a balance having sensitivity for a readable accuracy of 0.25 percent of load applied. Total weight of specimens shall be determined to nearest 0.25 percent and from this weight per ream calculated.

E-3. Thickness. Use test specimens not less than 2 in. by 2 in., free of wrinkles and creases, and a micrometer with two plane faces, the smaller of which is circular and 0.25 to 0.33 square inches in area. Micrometer faces must be parallel within 0.0002 in. and capable of repeating readings to 0.0001 in. on steel gage block. Clamp specimens between faces and under steady pressure of 7.0 to 9.0 pounds per square inch measure thickness to the nearest 0.0001 in. Reported thickness shall be the average of ten sheets so measured.

E-4. Tape Width. The width shall be measured on at least ten determinations of each roll spaced at least 6 in. apart. No one sample shall measure less than 0.683 in. nor more than 0.690 in.

E-5. Oil Content. The oil content of the tape shall be determined as follows: Place approximately ten grams of the oiled tape in a suitable extraction apparatus such as a Soxhlet or Underwriters and extract with carbon tetrachloride until all the oil is removed. Evaporate the solvent off in a water bath and weigh the residual oil. Dry the paper to constant weight at $105\text{ C} \pm 2\text{ C}$ ($221\text{ F} \pm 3.5\text{ F}$) and calculate the percentage of oil on the basis of the weight of the dry paper.

E-6. Tensile Strength. Using ten specimens 15 millimeters (0.5 in.) in width and not less than 140 millimeters (5.5 in.) in length in an accepted tensile strength testing instrument operated at a speed of 30.5 centimeters (12 in.) per minute, the paper must have the minimum breaking strength specified in the requirements for both machine and cross directions.

E-7. Folding Endurance. Using test specimens 15 millimeters (0.5 in.) in width, free from folds, wrinkles and blemishes, place in Schopper typefolding endurance tester and fasten ends firmly. Apply specified tension and fold the specimen tape at a uniform rate until it is severed at the crease. Record the number of folds required to sever the specimens, and using at least 20 specimens determine that their average meets the requirements.

E-8. Ash Content. The percentage of ash content shall be calculated by selecting de-oiled samples weighing not less than 1.0 gram, placing in a furnace operating at about 925 C (1700 F) and weighing the residue, after complete combustion, to the nearest 0.1 milligram. The average of two or more determinations shall be used.

E-9. Grit Content. To determine the grit content of the tape weigh out de-oiled specimens of approximately 25 grams. Use fuming HNO_3 and con-

concentrated H_2SO_4 and heat to remove the fibers and other solubles. After the solutions have been removed, weigh the dried residue using weights to the nearest 0.01 gram and calculate the percentage of grit.

F—Paper Make-Up

F-1. General. Colored tape shall meet these same specifications and the color desired must be specified on order.

F-2. Approximately the last ten feet of the tape shall be dyed red, or other distinguishable color, to indicate the end of the tape is being approached.

F-3. Rolls. The tape shall be wound on a pasteboard tube which shall have an inside diameter of two inches and shall be $\frac{1}{8}$ in. $\pm$ $\frac{1}{32}$ in. thick. The maximum outside diameter shall be 8 in., with all rolls as near to this diameter as practicable. Minimum acceptable diameter is 7 in.

F-4. Folded Tape. Customer's order shall specify the size of carton in which the tape is to be packaged. The tape shall not be compressed so tightly that the folds will crack or break under ordinary usage. The carton shall be so constructed that it can be used as a dispenser after a portion of the top is removed.

G—Identification

G-1. One face of each roll or carton shall bear the imprint of a rubber stamp giving the code number, manufacturer's name and the date of oiling.

H—Packing

H-1. The completed tapes shall be suitably packaged in oil-resistant paper and/or cartons and packed in heavy cartons to prevent damage in transit.

J—Warranty

J-1. The seller/contractor shall warrant that the material furnished under this specification shall be free from defects in design, material and workmanship. The seller's/contractor's obligation under this warranty shall not apply to any material which has been subject to misuse, negligence or accident after acceptance.

J-2. The seller/contractor shall covenant and agree to save harmless and indemnify the purchaser against all claims, suits, actions or proceedings, damages, costs, fees and expenses by reason of alleged infringement of patents, or for patent royalties involved, in consequence of the purchase or use of the material covered hereby.

Exhibit 7-D

NEW METHODS OF TYING AND FASTENING WIRES AND CABLES

Lacing twine is now available in addition to the standard waxed linen, in a number of new materials such as fiber glass and nylon.

Spiral wrapping devices made of plastic are available. Several sizes and materials are furnished. The wrapping device consists of a spiral ribbon of plastic slightly smaller in diameter than the bundle of wires to be tied. As the ribbon is being wrapped around the bundle of wires, individual wires may be fanned out between each coil of the spiral as desired.

Plastic tubing which may be closed by means of a slider is available in various diameters for wire jacketing purposes. One type is available which has shielding built in. The plastic material comes in a flat roll. It is formed into a tube around the wires to be bundled by engaging the tracks along the edge of the tubing with the slider provided. It may be unzipped and reused if desired. If permanent closure is required, a special sealant may be applied to fuse the tracks together. A special hand tool is available which will form the tube, close the tracks, and apply the sealant.

Plastic strapping devices are available in several sizes which are self-clinching or may be applied with special tools. These same devices may be used to mount electrical components or identification plates.

Among the advantages claimed for these new devices is that installation is faster than standard cable tying methods. One railroad reports increased output where communication racks are shop wired.

Exhibit 7-E

SPECIFICATION COVERING WIRE CHIEF EQUIPMENT
IN RAILROAD OFFICES, 2-J-1

E—Wire Testing Equipment—Physical Circuits

Recommend Addition of E-12:

E-12. Line Fault Analyzer. Electronic instrument which transmits pulses to circuit under test, with a reflected pattern of echoes on the face of the cathode ray tube. Change in continuity or impedance of normal circuit is indicated by abnormal upward or downward pips.

F—Carrier Testing Equipment

Recommend F-2 be changed as follows:

F-2. DB Meter. High impedance electronic voltmeter with db scale and a-c volts scale, reading directly in dbm when measurement is across 600 ohms. The range of frequency and level shall be consistent with the facilities to be tested.

Recommend addition of F-5, F-6, F-7 and F-8:

F-5. Impedance Matching and Isolation Transformers. As required.

F-6. Dial Pulse Generator. Generator should be adjustable to deliver dial pulses in the range of 8 to 14 pps, and percent break from 40 to 60 percent.

F-7. Dial Bias Distortion Measuring Set. Measuring set should be capable of measuring dial signaling bias and distortion for pulses in the range of 8 to 14 pps.

F-8. 1000-Cycle Generator. Generator should have a 600-ohm balanced output at levels of 0, minus 13 and minus 16 dbm. This could be the same generator as used for wire line testing specified in paragraph E-11.

G—Miscellaneous Testing Equipment

Recommend G-4 be changed as follows:

G-4. Telegraph Bias and Distortion Analyzer. An in service test set for telegraph signals of 60, 75, and 100 wpm measuring 20, 60 or 62.5 ma. neutral or polar signals.

Exhibit 7-F

	= BRIDGED TELEPHONE SET
	= CARRIER TERMINALS SHOWING NUMBER OF CHANNELS
	= COMPOSITE SET
	= LINE FILTERS WITH CARRIER REPEATER AND VOICE REPEATER
	= POLE MOUNTED FILTER LOW PASS 'IN' FOR TEST, HIGH PASS BYPASSED
	= CARRIER REPEATER
	= TELEPHONE REPEATER
	= TELEGRAPH REPEATER
	= REPEAT COIL
	= TELEPHONE CIRCUIT LOOPS FOR TEST
	= TELEPHONE CIRCUIT LOOPS FOR TEST, WITH TELEPHONE SET CONNECTED
	= TELEGRAPH CIRCUIT LOOPS FOR TEST
	= TELEGRAPH INSTRUMENT CONNECTED
	= IMPEDANCE MATCHING AUTOTRANSFORMER
	= IMPEDANCE MATCHING TRANSFORMER
	= ALUMINUM WIRE
	= ALUMINUM COVERED WIRE
	= COPPER WIRE
	= COPPER COVERED WIRE
	= IRON WIRE
	= LEASED OR FOREIGN WIRE
	= BATTERY SUPPLIED TO WIRE
	= GROUNDED WIRE

Symbols for Use on Testboard Wire Chart
C-2215

March, 1932; January, 1957; June, 1962

EAST AND WEST RAILROAD

TESTBOARD CHART OF WIRES AND OFFICES BY LINES

--- MILWAUKEE --- LINE BETWEEN --- MILWAUKEE --- AND --- CHICAGO ---

FROM --- MILWAUKEE --- TEST OFFICE

DISTANCE	NAME OF OFFICE	OFFICE HOURS	TELEG. CALL	TYPE OF SWITCHBD	SELECTOR CODE	CIRCUIT DESIGNATION				
						1-SX 1-TK	2-SX 1-2-TK	3-SX 3-DIS.	4-SX 4-MSG.	9
0	MILWAUKEE	CONT.	GO	T.B.	2-2					
4.1	CHASE AVE. CABLE POLE									
7.1	LAKE TOWER	CONT.	X	T	2-3					
19.0	FRANKSVILLE	7A-4P	K	U	2-4					
23.2	STURTEVANT	CONT.	CS	T	2-5					
32.4	TRUESDELL	8A-5P	SD	U	2-6					
38.0	RUSSELL	8A-5P	U	U	2-7					
42.1	WADSWORTH	CONT.	U	T	2-8					
46.4	GURNEE	7A-4P		U	2-9					
52.7	ROUNDOUT	CONT.	RO	T	2-10					
61.1	DEERFIELD	6A-3P	D	U	3-2					
64.1	NORTHBROOK	6A-3P	SR	U	3-3					
64.7	TOWER A-20	CONT.	CN	T	3-4					
67.6	GLENVIEW	6A-3P	GV	U	3-5					
70.7	MORTON GROVE	6A-3P	MN	U	3-6					
73.6	HEALY	6A-3P		U	3-7					
79.6	TOWER A-5	CONT.	CJ	T	3-8					
82.1	TOWER A-2	CONT.		T	3-9					
85.0	CHICAGO	CONT.	CG	T.B.						

C-2216

June, 1962

(Sheet 2)

Exhibit 7-G

ADDITIONS TO
A GENERAL DESCRIPTION OF PRINTING TELEGRAPH APPARATUS
AND ITS APPLICATION TO RAILROAD SERVICE, 2-K-23ADDENDUM TO APPENDIX NO. 2
DESCRIPTION OF TELETYPE MODEL 28 EQUIPMENT

A—Purpose

A-1. This addendum to Appendix No. 2 on Teletype Model 28 equipment is intended to describe various modifications to the equipment which are obtainable either in kit form or when specified on new units.

B—Multiple Wire Output from Fixed Head Transmitter Distributor

B-1. The fixed head single contact transmitter distributor C-4047 described in Q-1 of Appendix No. 2 can be modified or purchased for multiple wire (parallel) output. The modification kit is described and its installation procedures outlined in Teletype Corp. specification 5939-S.

B-2. With the multiple wire output equipment on the transmitter, the transmitter will simultaneously produce both its standard serial output and the parallel multiple wire output. In addition to the five parallel code reading outputs there is a timing contact for control of associated equipment.

B-3. When purchasing a new transmitter, it can be obtained with either simultaneous serial and parallel outputs, serial only output or parallel only output.

Appendix No. 3

DESCRIPTION OF TELETYPE HIGH SPEED TAPE
READING AND PUNCHING EQUIPMENT

A—Purpose

A-1. This appendix is intended to serve as a guide to those whose duty it is to arrange for, operate and maintain model CX-110 reader and BRPE-110 punch equipment.

B—Drawings and Specifications

B-1. Drawings included and referred to:

Drawing C-5083—Tape Reader

Drawing C-5084—High Speed Tape Punch

B-2. Technical Manuals of Teletype Corporation:

Bulletin 267-B Tape Reader Set (CX)

Bulletin 215-B High Speed Tape Punch Set (BRPE)

C—Tape Reader Set

C-1. The high speed tape reader can read chadless or fully perforated one inch paper tape with 5, 6, 7 or 8 level codes. The tape guides can be readily adjusted to accommodate $\frac{1}{16}$ in. tape with 5 level code; or $\frac{3}{8}$ in. tape with 6 level or 7 level codes. Speeds up to 107.14 characters per second are available.

C-2. The unit provides multi-wire (parallel) simultaneous output corresponding to the intelligence in the tape. Two timing contacts that operate simultaneously with the sensing pins are provided for controlling external circuits. The reader is equipped with a magnetic pickup, which generates a pulse whose occurrence is adjustable, to actuate control circuits of associated apparatus.

C-3. A start-stop lever, tight-tape mechanism and end-of-tape mechanism are a part of each unit. The control magnet operates on 28 volts d-c at one ampere. External resistance must be provided. A control magnet coil is available for operation on 115 volts 0.1 ampere. External resistance is also required.

C-4. Additional information on the reader is contained in Teletype Bulletin 267B. The tape reader is shown in Drawing C-5083.

D—High Speed Tape Punch

D-1. The high speed tape punch set is capable of fully perforating paper tape at rates up to 110 characters per second in response to multiwire (parallel) simultaneous input. The sets are available for perforating 5 level code in $\frac{1}{16}$ in. tape or 8 level code in 1 in. tape. The latter may be readily readjusted for perforating 6 level or 7 level codes in $\frac{3}{8}$ in. tape.

D-2. There is a choice between two types of code magnets:

- (1) For 28 volts 1 ampere for transistor type of operation, or
- (2) For 115 volts 0.150 ampere for vacuum tube type of operation.



Tape Reader
C-5083
June, 1962

D-3. Since the punch cycles continuously, the feed and code pulses must be introduced at a specific time (within certain limits) to be properly processed. A magnetic pickup is provided to trigger external signal storage. A simplified range adjuster is used in conjunction with the magnetic pickup to insure signal transfer at the optimum point of the operating cycle.

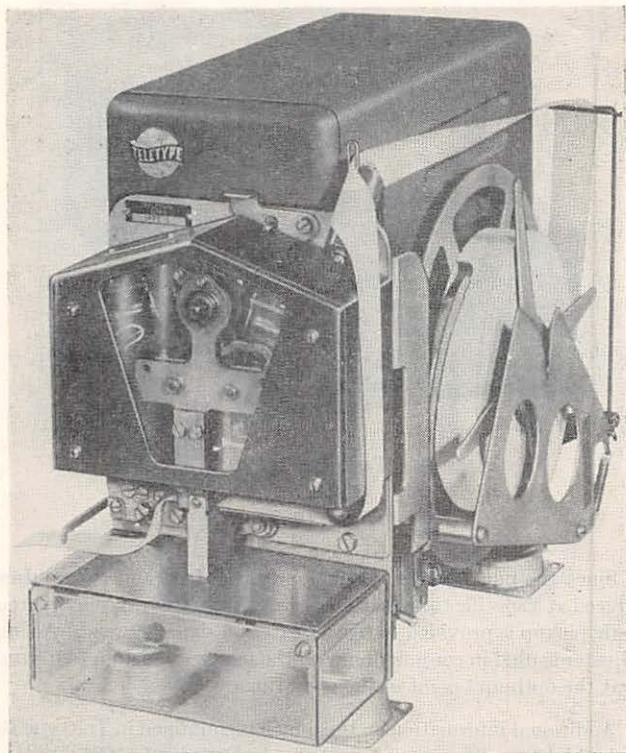
D-4. Additional information on the punch is contained in Teletype Bulletin 215B. The high speed tape punch is shown in Drawing C-5084.

E—Method of Control and Synchronization

E-1. The tape reader and high speed tape punch are not designed to be connected to each other without a set of control equipment. As stated in Section C-2, the tape reader has separate parallel outputs for each level of information in any one character, two universal timing contacts and a magnetic synchronizing pulse.

E-2. The Teletype Corporation has a transmitter signal converter and transmitting distributor to which the several parallel outputs of the tape reader are connected and in which the information is converted to serial type signals. The distributor has an output of -6 volt d-c for marking and $+6$ volt d-c for spacing on a single circuit. This single output can be used to control various types of high speed methods of transmission and was designed to control a Bell System Data-Phone Set. The reader's magnetic pickup output and universal contact closures are used to control the cycling of the distributor.

E-3. At the reader end of the circuit the output of the transmission equipment or Bell System Data-Phone Set produces a serial type signal similar to the one produced at the output of the transmitter distributor. This signal must have a voltage in excess of -3 volt d-c for marking and $+3$ volt d-c



High Speed Tape Punch
C-5084
June, 1962

for spacing. This serial type signal is used as an input to a Teletype Receiving Signal Converter and Receiving Distributor. The receiving distributor has storage facilities capable of storing one character at a time for subsequent application to the tape punch. The distributor converts the serial input signal into parallel wire form.

E-4. The tape punch is a synchronous type unit and is run at a slightly higher speed than the tape reader. The punch when operating is a constantly rotating unit with no provisions for synchronizing its rotation with that of the tape reader. When the punch is operating the output of its magnetic pulse is used to release a stored character from the distributor if the distributor has a character in storage. If the distributor does not have a complete character in storage when the pulse is received, no impulses will be sent to the tape punch and it will neither punch nor feed tape for that rotation. Because the punch is operating faster than the reader it will always be ready to receive a signal from the distributor storage before the next character must be fed into the storage unit and it will be necessary for the punch to rotate without operating at certain times during its operation to wait for a signal from the slower reader.

Exhibit 7-H

DIALING ON MESSAGE TELEPHONE CIRCUITS

* Since the last reports another system is available to perform the functions of dialing on message circuits. Essentially, the primary operation of starting a call from the waystation is similar to that explained in the previous report. Figure 1 shows the general arrangement of the system.

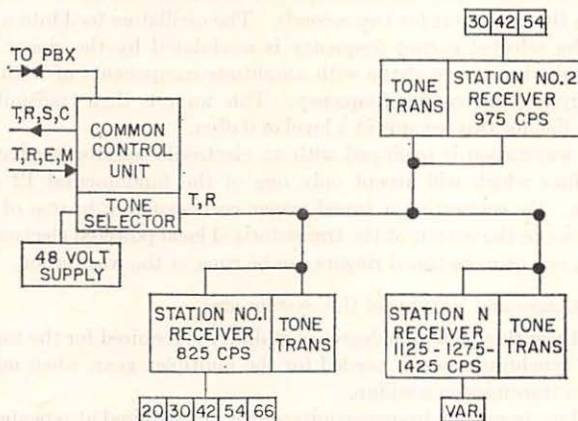


Fig. 1

In this new system a transistorized oscillator introduces 2350 CPS at the waystation to the line in the form of pulses, which are controlled by a dial. These pulses cause certain apparatus at the terminal to start the operation and store the code, after which the desired party is signaled at either an automatic telephone station, a station on another message circuit or another station on the same message circuit.

Two systems of ringing are provided for signaling on the conventional message lines. The first is by the conventional alternate direct current pulses, which operate the 60 Type selectors at the waystation and ring a bell in the usual way. The second method introduces an innovation in that the waystation is alerted by sending out from the terminal a series of varied and coded tone signals to an electronic selector receiver at the waystation, which operates an audible signal. This method of signaling provides faster operation by the substitution of electronic selector receiver for the conventional a-c type of selector signaling.

A brief description of the operation of the equipment at the terminal which supplies the variable frequency tones to the waystation receiving equipment is as follows:

When the last digit is dialed into the office receiving equipment from a waystation or other automatic dial station to ring a waystation the transmitting

* 1960 Communications Proceedings, p. 59.

selector equipment is set in motion. A memory matrix sets two oscillators, the carrier oscillator and the ringer oscillator. The ringer oscillator has five different frequencies corresponding to a non-harmonic tuned ringer series as follows: 20, 30, 42, 54 and 66 cycles per second. The carrier oscillator can be set by the relay matrix for one of 12 different frequencies beginning at 525 CPS, 150 cycles apart as follows: 525, 675, 825, 975, 1125, 1275, 1425, 1575, 1725, 1975, 2025 and 2175 cycles per second.

The five ringer frequencies and the 12 carrier frequencies can be combined in 60 different ways enabling one to choose up to 60 stations.

After the dialed code has been read out of the memory unit, a timing circuit turns on the oscillators for two seconds. The oscillators feed into a modulator where the selected carrier frequency is modulated by the ringer frequency. This results in a wave shape with amplitude components of both the ringer frequency and the carrier frequency. This wave is then transmitted to the message line for two seconds at a level of 0 dbm.

Each waystation is equipped with an electronic selector receiver having a tuned filter which will accept only one of the fundamental 12 carrier frequencies. By connecting a tuned ringer corresponding to one of the ringer frequencies to the output of the transistorized local powered electronic selector receiver, one or more tuned ringers can be rung at the waystation.

Advantages and features of this system are:

(1) Even though a high degree of stability is required for the tone frequencies, no synchronization is needed for the multiplex gear, when microwave is used as a transmission medium.

(2) Low frequency by-pass equipment is not required at repeater locations.

(3) The waystation equipment requires only the usual 4.5 volt d-c supply and will continue to operate when the voltage drops as low as 3 volts.

(4) This system has a large degree of flexibility which allows it to be installed in several phases. The design of the control unit is such that it can be converted with a minimum of effort from the 60-type selection to tone selection. Other features allow for progression from basic automatic dialing with mechanical features to the ultimate, completely automatic dialing system, since each piece of equipment lends itself to this progression without appreciable additional over-all cost.

The purpose of this report is to alert the prospective user of message circuit dialing to the availability of equipment with the advanced features outlined herein.

Exhibit 7-I

APPARATUS AVAILABLE FOR INTER-CITY DIALING

The advent of long distance dialing has presented additional transmission and economic problems. In normally operated manual switchboards, repeaters and pads were inserted in long distance circuits where they were connected for through service so as to raise or lower the transmission level and provide constant and workable levels for end-to-end telephone service.

With inter-city dialing circuits consideration must be given to the extent of through dialing, whether tandem service will suffice or whether through terminal-to-terminal service must be provided or, perhaps, a combination of both.

Four-wire switching is more adaptable than two-wire switching to some switching requirements. It also affords certain transmission benefits and might be better suited to the handling of some data communications. Two-wire systems in general can be made to meet all normal transmission requirements but this may involve more critical circuit design and maintenance. Presently, there are no firm guide lines that can be used to determine the general applications of four-wire or two-wire systems. Each individual system requirement governs whether four-wire or two-wire is best suited for the job.

The telephone companies may furnish two units of equipment for dialing service; a "four-wire terminating set" and a "dial trunk circuit" to be connected to a railroad-provided, inter-city carrier telephone facility arranged with dialing gear. Four-wire terminating set, usually included in the carrier terminal, switching relay and terminating pad may be furnished by the railroad. A grounding lead can be furnished from the central office equipment to operate the switching relay when two carrier circuits are connected through an office on a tandem basis.

Four-wire to two-wire terminating sets are likewise available for four-wire tandem switching where this type facility is required. With the aid of controlling leads from the automatic exchange selectors and repeater equipment, the four-wire sets can be installed by the railroad companies, or they may be furnished by the telephone companies on the usual rental basis.

Facilities to provide the "E" and "M" dialing leads for carrier or physical telephone circuits not otherwise provided are available and can be derived or supplied by various means—physical, simplex, composite, telemetering, speech plus, carrier, etc., as outlined in the 1961 Report* of Subcommittee 7-B.

Equipment can be provided by the telephone company for either two- or four-wire switching. Equipment for four-wire switching of long distance dialing telephone circuits is available from various telephone supply companies.

* Various Methods of Deriving "E" and "M" Leads for Direct Distance Dialing on various Types of Circuits. 1961 Advance Reports, Communication and Signal Section, p. 323.

REPORT OF

COMMITTEE 8—HIGHWAY GRADE CROSSING PROTECTION

-
- A. C. Jacobsen (Chairman), Assistant Signal Engineer, Southern Pacific Company.
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H. A. Appleby, Signal Engineer, Atchison, Topeka and Santa Fe Railway.
W. E. Blevins, Office Engineer-Signals, Missouri Pacific Railroad.
J. W. Gavey, Project Engineer-Signals, Western Pacific Railroad.
E. W. Horning, Crossing Protection Engineer, Chicago and North Western Railway.
E. A. Krause, Signal Engineer, Union Pacific Railroad.
B. F. McGowan, Assistant Chief Engineer Signals and Communications, Soo Line Railroad.
C. J. Mullen, Supervisor Communications and Signals, Central Vermont Railway.
O. S. Penman, Supervisor of Signals, Reading Company.
E. J. Seybold, District Signal Engineer, New York Central Railroad.
C. L. Summers, Assistant to General Superintendent Communications and Signals, St. Louis-San Francisco Railway.
D. H. Thomsen, Assistant to Chief Signal Engineer System, Burlington Lines.
H. W. Trawick, Assistant Engineer of Signals, Canadian Pacific Railway.
C. N. Tymeson, Chief Circuit Engineer, Baltimore and Ohio Railroad.
R. B. Whalen, Field Engineer Signals, Boston and Maine Railroad.
O. M. Wiland, Engineer Communications and Signals, Pennsylvania Railroad.

Consulting Members

- A. T. Johnston, Consulting Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
R. J. Little, Standards Engineer, General Railway Signal Company.
D. M. Noell, Chief Signal Engineer, Board of Transport Commissioners for Canada.
H. M. Taylor, Jr., Senior Office Engineer (Civil), State Highway Department of Texas.
R. B. Thomas, Chief Engineer, Illinois Commerce Commission.
D. H. Worcester, General Signal Supervisor, Chicago Transit Authority.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.

3. Report on noteworthy developments in highway grade crossing protection.
5. Develop annual cost of automatic highway grade crossing protection devices exclusive of installation costs.
6. Investigate and report on methods to improve effectiveness of railroad-highway grade crossing protection devices.
7. Investigate and report on the advisability of discontinuing the use of STOP ON RED SIGNAL and STOP WHEN SWINGING signs.
8. Investigate and report on signs used at or near highway grade crossings to caution drivers of vehicles not to stop on tracks.

The committee submits for consideration, reports on the following subjects:

1. **Revision of Requisites for Highway Grade Crossing Signals and Devices**, as Exhibit 8-A, page 145, to supersede Signal Manual Part 148.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

1. **Removal from Signal Manual of Drawings 1553—Disc for Wig-Wag Highway Crossing Signal and 1651F—Highway Crossing Signal—Wig-Wag Type with Stop When Swinging Sign—Assembly.** In line with revision of Signal Manual Part 148, in which reference to wig-wag signals has been deleted, the committee recommends that these drawings be removed from the Manual.

Action Recommended

Acceptance for submission to letter ballot for elimination from the Signal Manual.

1. **Deletion of all signs, other than the crossbuck, from drawings of highway crossing signals in the Signal Manual.** The committee recommends that all signs, other than the crossbuck, such as "NUMBER OF TRACKS," "STOP ON RED SIGNAL" and "STOP WHEN SWINGING," be removed from drawings of highway crossing signals in the Signal Manual.

Action Recommended

For discussion.

3. **Report on Noteworthy Developments in Highway Grade Crossing Protection.** Wide publicity in both the United States and Canada has been given to a proposal of installing a warning radio transmitter on each train and a receiver on every school bus or other vehicle to warn the driver of an approaching train.

Contrary to some reports, the committee was unable to develop any instance where such a device has been installed.

Nothing has been presented to the committee to indicate any major development which would make this proposed form of protection meet the basic requirements of safety and reliability nor is there any indication that the warn-

ing system will offer any selectivity between crossings near the train and those remote, resulting in possible confusion and indecision on the part of the driver of the vehicle.

With the information available and the present state of development of the art of transmitting and receiving radio signals, the committee is unable to recommend or consider testing such form of protection. Reliability and assurance against failure to operate as intended are prime requisites of a crossing protection system.

Action Recommended

Acceptance as information.

5. Annual Cost of Automatic Highway Grade Crossing Protection Devices, Exclusive of Installation Costs. In line with the report of the committee presented at the 1961 annual meeting (Exhibit 8-D, page 340 of Advance Reports), the committee has progressed its survey and 39 Member Roads are cooperating, reporting upon 75 crossings under the various classifications as listed in last year's report. The starting date of the survey was July 1, 1961. The committee expects to complete the report during the latter part of this year.

Action Recommended

Acceptance as information.

6. Report on Methods to Improve Effectiveness of Railroad-Highway Grade Crossing Protection Devices, as Exhibit 8-B, page 147.

Action Recommended

Acceptance as information.

8. Report on Signs Used at or Near Highway Grade Crossings to Caution Drivers of Vehicles Not to Stop on Tracks, as Exhibit 8-C, page 148.

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 8—HIGHWAY GRADE CROSSING PROTECTION

Exhibit 8-A

(Revision of AAR Signal Section Requisites for Highway Grade
Crossing Signals and Devices)
AAR SIGNAL REQUISITES

HIGHWAY GRADE CROSSING SIGNALS AND DEVICES**1962****1. Purpose**

(a) These requisites are for the purpose of setting forth the recommended general requirements for highway grade crossing signals and devices. They set forth specific detail requirements representing modern signal practice recommended for new installations and for replacement of existing installations when general renewal or replacement is made.

2. Signals and Devices

- (a) Flashing light type signal shall conform to Drawing 1653, 1686 or 1688.
- (b) Flashing light type signal with gate shall conform to Drawing 1462 or 1489.
- (c) "No Right Turn" or "No Left Turn" signal shall conform to Drawing 1488.
- (d) Bell shall be in accordance with Specification 44, Manual Part 21.

3. Application

- (a) Flashing light type signal will be used with or without gates.
 - 1. One signal shall be placed on each side of the track, except that on one way thoroughfares, signals shall be placed on side of approaching traffic.
- (b) When a gate is used with a signal conforming to Drawing 1686 or 1688, it may be separately mounted on a pipe post or pedestal adjacent to the signal, preferably between the signal and the track.
- (c) On highways adjacent to and approximately paralleling a railroad, which intersect or join another highway that crosses the railroad at grade, "No Right Turn" or "No Left Turn" signal may be used to supplement highway grade crossing signals which are located at the crossing.
- (d) Bell may be used when required by public authority or special conditions.

4. Location

- (a) Flashing light type signal, with or without gate, shall be placed preferably to the right of approaching highway traffic and should conform to Drawing 1730, 1731, 1732, 1733, 1734, 1735, 1736, 1737, 1738, 1739, 1740, 1741 or 1742. Additional light units or an additional signal may be used if it is determined to be impracticable to protect all highway traffic approaching the crossing from one direction with a single signal.
- (b) "No Right Turn" or "No Left Turn" signal shall be placed as close to the intersection as practicable.
- (c) Bell should be mounted preferably on the mast supporting the crossing signal, with the face of the gong parallel to the highway.

5. *Operating Requirements*

(a) Flashing light type electric light units shall be in accordance with Specification 190, Manual Part 166, or Specification 232, Manual Part 244.

1. Electric lamps shall flash alternately. The number of flashes per minute of each electric lamp shall be 30 minimum, 45 maximum.

2. Electric lamps shall be illuminated approximately the same length of time. Total illuminated time of each pair of electric lamps shall be practically the entire operating time.

(b) Gate arm, when in the raised position, shall not obstruct or interfere with highway traffic.

1. Electric motor mechanism shall be in accordance with Specification 199, Manual Part 194.

2. Gate arm shall conform to Drawing 1491, 1492, 1493 or 1494.

3. Electric light units on gate arm shall be in accordance with Specification 236, Manual Part 263.

(c) Illuminated indicators and signs shall be in accordance with Specification 231, Manual Part 237.

(d) Size and range of bell shall be determined by local conditions.

(e) Controls for operation of highway grade crossing signals and devices shall be in accordance with Requisites for Control of Automatic Highway Grade Crossing Signals and Devices, Manual Part 274.

(f) Installation of highway grade crossing signals and devices shall be in accordance with Specification 176, Manual Part 149.

6. *Painting*

(a) Painting shall be in accordance with Instructions for Painting, Manual Part 110. All metal parts which do not function as hoods or backgrounds for signals employing lights shall be given a finishing coat of aluminum when installed.

7. *Highway Marking*

(a) At railroad-highway grade crossings the highway traffic lanes in the vicinity of the crossing should be marked in accordance with the Manual on Uniform Traffic Control Devices for Streets and Highways.

Exhibit 8-B**REPORT ON METHODS TO IMPROVE EFFECTIVENESS OF
RAILROAD-HIGHWAY GRADE CROSSING PROTECTION DEVICES**

This subject is one of continuing interest to the members and others, and this report lists some of the devices and suggestions considered by the manufacturers and railroads for the purpose of providing a more arrestive indication, where competition from other light sources is experienced yet at the same time retaining the reliability and fail safe principles of the present system.

The devices include:

- Rotating mirror light, as used by emergency vehicles
- Rotating sealed-beam light
- Condenser discharge tubes
- 12-inch roundels
- Traffic lights
- 8-lamp unit circular light signal with progressive lighting

Among the suggestions are:

- Change in rate of flashing
- Increased wattage of lamps
- Rearrangement of light units and sequence of flashes
- Color striping of gate arms to provide the best contrast relative to the background in place of present black and white recommendation

While the devices listed above may appear to be acceptable adjuncts, they are not at this time suitable for universal application.

Exhibit 8-C

REPORT ON SIGNS USED AT OR NEAR HIGHWAY GRADE
CROSSINGS TO CAUTION DRIVERS OF VEHICLES
NOT TO STOP ON TRACKS

This assignment is for the purpose of determining what, if any, signs are used to caution drivers of vehicles not to stop on tracks where highway-railroad grade crossings are in close proximity with highway intersections and the probability exists for highway vehicles to stop on the tracks when stopping for the intersection; also the effectiveness of such signs.

Information received from committee members indicates that such signs are used sparingly and can be summarized as follows:

Legends used	—“Do Not Stop on Tracks” “Warning Railroad Crossing Do Not Stop On Tracks” “Wait Here For Clear Space Beyond Tracks” “Automatic Signal Keep Clear” “Caution Stay Clear of Tracks When Traffic Ahead Stops”
Dimensions	—Various
Color	—Black letters—white or silver background White letters—black background Silver letters—red background
Painted, Reflectorized, or Illuminated	—Varied
Mounting	—Post mounted Suspended overhead Mounted on signal mast
Installation Made By	—Public Highway Authority except Railroad in few instances upon request of public authority
Effectiveness	—Depending upon enforcement
Enforcement	—Questionable depending on local authority
Standardization of Sign by Railroad	—None

The investigation of the use of signs at crossings where vehicular traffic may stack on the tracks in congested areas reveals lack of uniformity in the design and application of the sign including legends used, dimensions, color and location. The matter of observation and enforcement appears also to be inconsistent, and for these reasons the effectiveness of the signs as they are now applied is open to question.

The committee is of the opinion that since the problem of vehicles stacking on the track is highway traffic-generated, over which the railroad has no control or effective means to prevent, the responsibility for relieving the situation rests with the governmental subdivision having jurisdiction over the particular vehicular roadway.

REPORT OF
COMMITTEE 9—TRANSMISSION

- P. A. Flanagan (Chairman), Superintendent Communications, Chesapeake and Ohio Railway System.
C. O. Jett (Vice-Chairman), Assistant Superintendent Communications, Union Pacific Railroad.
J. M. Hesser, Assistant Superintendent Signals and Communications, Norfolk and Western Railway.
John Mooney, Jr., Engineer Electronics, Pennsylvania Railroad.
J. L. Nash, Communications Engineer, New York, Chicago and St. Louis Railroad.
L. J. Ritter, Superintendent Communications, New York Central System.
R. T. Rivers, Communications Engineer, Southern Railway System.
J. H. Wallis, Communications Engineer, Baltimore and Ohio Railroad.
C. G. Webster, System Planning Engineer, Telecommunications Department, Canadian National Railways.
R. G. Zvara, Assistant Engineer Communications, Erie-Lackawanna Railroad.

Railroad Consulting Member

- C. L. Durban, Manager of Systems Development, Missouri Pacific Railroad.

Consulting Members

- R. L. Berube, Administrative Assistant to Director of Engineering, Kleinschmidt Division of Smith-Corona Marchant Inc.
F. B. Bramhall, Engineering Consultant, Lenkurt Electric Company.
A. B. Covey, Special Transmission Facilities Engineer, Department of Operation and Engineering, American Telephone and Telegraph Company.
R. J. Derr, Communications Planning, International Business Machines Corporation.
K. R. Fox, Director, Microwave Division, Collins Radio Company.
Harry Jones, Supervisor of Transmission, Communications Systems Department, ITT-Kellogg.
W. L. Long, Manager, Transportation Marketing, Remington Rand Univac, Division of Sperry Rand Corporation.
A. F. Perkins, Chief of Advanced Development, General Dynamics/Telecommunications.
J. N. Petrie, Chief Transmission Engineer, Automatic Electric Company.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.

3. Study and report on new methods of measuring transmission performances on teleprinter and data circuits.
4. Investigate and report on transmission systems suitable for frequencies up to 10 mc, other than free space propagation (a) short haul (b) long haul.
5. Investigate and report on communication techniques to aid in the application of data processing systems.
6. Investigate and report on fundamental considerations in connection with data transmission.
7. Investigate and report on latest developments in high speed data transmission techniques and error detection systems.
8. Investigate and report on minimum requirements for telephone transmission network design to provide long distance switched networks.
9. Investigate and report on the source and effect of impulse noise on voice communication, signal and data transmission circuits.
10. Investigate and report on the effects to both signal controls and communications when signal circuits and communications circuits are operated on the same wires or other media.
11. Investigate and report on approach to integrated communications involving telegraph, telephone and data, all within the same system.
12. Investigate and report on new transmission measuring techniques.
13. Investigate and report on the joint use of CTC code lines for dispatcher's telephone and communication carriers, and if deemed advisable prepare recommended practices for such joint use.

The committee submits for consideration, reports on the following subjects:

1. Revision of Telegraph System Design, 11-6. This part of the Communication Manual was reviewed with the intent to include high speed operations. Paragraph G-3 has been revised as quoted below to include 100-speed printer operation and Tables 1 and 2 have values added for 100-speed printer operation. The revised tables appear in Exhibit 9-A, page 152.

G-3. The telegraph transmission coefficients given in Table 2 apply to 60, 75 and 100 words per minute printer operation with five unit selecting codes. They are also applicable with certain modifications as noted in Item 8, Manual Telegraph Circuits, of Table 2, to fast manual transmission in the order of 30 to 35 words per minute.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Communication Manual.

3. Report on New Methods of Measuring Transmission Performance on Teleprinter and Data Circuits, as Exhibit 9-B, page 156.

Action Recommended

Acceptance as information.

5. Data Transmission Over Voice Channels, as Exhibit 9-C, page 157.

Action Recommended

Acceptance as information.

9. Impulse Noise— Sources and Effects, as Exhibit 9-D, page 173.

Action Recommended

Acceptance as information.

9. Impulse Noise Versus Digital Data, as Exhibit 9-E, page 185.

Action Recommended

Acceptance as information.

9. The committee wishes to call attention to a paper entitled "Evaluation of Data Transmission and Coding on a Large Multi-point Network", by Messrs. L. L. Corbett, M. Gordon and T. S. Stafford, which is available from IBM Development Labs Data Systems Division.

Action Recommended

Acceptance as information.

10. Report on the Effects to Both Signal Controls and Communications When Signal Circuits and Communication Circuits are Operated on the Same Wires or Other Media, as Exhibit 9-F, page 191.

Action Recommended

Acceptance as information.

12. Report on New Transmission Measuring Techniques, as Exhibit 9-G, page 195.

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 9—TRANSMISSION

Exhibit 9-A

TELEGRAPH SYSTEM DESIGN, 11-6
REVISED TABLES 1 AND 2

TABLE 1

Multiplication Factor for Determining
"Equivalent Lengths"

Composition Of Facility	Simplex Pair		Composited		Type of Circuit To Be Used For Assigning Coefficient
	Cable	Open Wire	Cable	Open Wire	
All Cable	1	—	1	—	Predominant Part
All Open Wire	—	1	—	1	Predominant Part
Cable and Open Wire					
(a) Predominant part is a cable portion	1	$\frac{1}{3}$	1	$\frac{1}{3}$	Predominant Part
(b) Predominant part is an open wire portion	3	1	3	1	Composited open wire

Note:

1. The above multiplication factors for cable portions may be applied also to any length of toll entrance cable.

2. The multiplication factors given under Cable and Open Wire (b) apply only to composite and simplex circuits. Therefore, the type of circuit to be used for assigning a coefficient has been designated as composited open wire. In cases where the predominant part of the circuit is single conductor open wire the coefficients given under composited open wire may be lowered somewhat.

TABLE 2

Transmission Coefficients For 60, 75 and 100 Speed Teletype Circuits

∠ Indicates sections of length less than the distance given.

∇ Indicates sections of length greater than the distance given.

Type of Telegraph Repeater Section	Miles	Speed		
		60	75	100
1. Carrier Channels				
In applying the coefficients for carrier systems, caution should be exercised to be certain that the derived telegraph channels lie wholly within the flat band of the transmission facility. These values are applicable to any well designed voice frequency carrier telegraph system with 170-cycle spacing.	∠ 1500 ∇ 1500	1.8 2.2	2.8 3.2	4.5 5.0

2. Differential Duplex-Half Duplex	Miles	Speed		
		60	75	100
(a) Using Polar Duplex Type Repeaters 1-wire (ground return) operation.				
Cable Circuits				
16, 19 or 22 ga. Single Conductor	∠100	2.4	4.0	*
Simplexed Pair	∠100	3.0	5.0	*
Open wire circuits 104, 114, 128 mil				
Single Conductor	∠200	2.4	4.0	*
Simplexed Pair	∠200	3.0	5.0	*
Composited, no ICX**	∠150	2.6	4.0	*
	150—250	2.9	5.0	*
Composited, one ICX	∠170	2.7	4.0	*
	170—250	3.3	6.0	*
165 mil				
Single Conductor	∠225	2.4	4.0	*
Simplexed Pair	∠225	3.0	5.0	*
Composited, no ICX	∠250	2.4	4.0	*
	250—350	2.7	5.0	*
Composited, one ICX	∠250	2.8	5.0	*
	250—350	3.3	6.0	*
(b) Using Polar Duplex Type Repeaters 2-wire (neutralizing wire) operation				
Cable Circuits				
16, 19 or 22 ga. Single Conductor	∠100	2.4	3.2	1.8
Simplexed Pair	∠100	3.0	4.0	5.0
Open wire circuits 104 or 114 mil				
Single Conductor	∠200	2.4	3.2	4.8
Simplexed Pair	∠200	3.0	4.0	5.0
Composited, no ICX	∠125	2.0	3.5	4.5
	125—225	2.3	4.0	5.5
Composited, one ICX	∠225	2.6	3.5	5.0
	225—300	3.0	4.0	6.0
128 Mil				
Single Conductor	∠225	2.4	3.2	4.8
Simplexed Pair	∠225	3.0	4.0	5.0
Composited, no ICX	∠150	2.0	3.5	4.5
	150—250	2.3	4.0	5.5
Composited, one ICX	∠250	2.6	3.7	5.0
165 Mil				
Single Conductor	∠225	2.4	3.2	4.8
Simplexed Pair	∠225	3.0	4.0	5.0
Composited, no ICX	∠200	2.0	3.5	4.5
	200—300	2.3	4.0	5.5
Composited, one ICX	∠300	2.5	3.7	5.0

* Not recommended.

** Intermediate composite.

	Miles	Speed		
		60	75	100
3. Polarential				
With Polar Duplex Type Repeaters	Use the coefficients given under (7), (a1), (a2), (b1)			
4. Up-Set Duplex to Voltage at Distant Office				
	∠60	3.5	5.0	*
Using Polar Duplex Type Repeaters	60—100	3.8	5.5	*
any type of facility	100—150	4.5	7.0	*
	150—180	5.3	—	*
5. Neutral Telegraph				
(a) Simplex Cable	∠30	3.0	4.0	*
	30—50	3.5	5.0	*
	50—60	4.0	6.0	*
Composited Open Wire	∠40	3.5	5.0	*
(b) Single line or hub repeater in the path of transmission to branch circuits or legs		0.3	0.5	0.7
6. Loop Circuits				
Assuming proper wave shaping and printers equipped with pulling magnets for 60 speed and holding magnets for 75 speed	0—1	0.2	0.4	0.6
	1—10	0.5	0.7	1.0
	10—20	1.0	1.2	1.7
	20—30	1.5	1.9	2.8
	30—38	2.2	2.8	4.0
7. Outlying Point Circuits				
(a) Polarential Type A (Series res. compensation) with Polar Duplex Type Repeaters at one office				
(a1) 1-wire (ground return) operation with WE, 128B2 at outlying point				
Cable Circuits				
16, 19 or 22 ga.				
Single Conductor	∠50	2.4	4.0	5.5
	50—100	3.4	4.8	*
Simplex Pair	∠50	3.0	5.0	*
	50—100	4.2	6.0	*
(a2) 2-wire (neutralizing wire) operation with WE128B2 at outlying point				
Cable Circuits				
16, 19 or 22 ga.				
Pair	∠50	2.2	3.5	4.7
	50—75	2.8	4.6	5.8
	75—100	3.2	5.0	6.4
Simplex Pair	∠50	2.4	3.5	4.7
	50—75	2.8	4.6	5.8
	75—100	3.2	5.0	6.4

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9—Transmission

	Miles	Speed		
		60	75	100
(b) Polarential Type B (leakage compensation) Polar Duplex Type Repeater at one office and 128B2 at outly- ing point				
(b1) 1-wire (ground return) operation				
Open Wire Circuits any gage				
Single Conductor	∠75	2.4	4.0	5.5
	75—150	3.4	4.9	*
Simplexed Pair	∠75	3.0	5.0	*
	75—150	4.2	6.2	*
Composited, no ICX	∠100	2.5	4.5	*
	100—150	2.8	4.8	*
	150—200	3.1	5.0	*
Composited, one ICX	∠100	2.7	5.0	*
	100—150	3.2	5.5	*
	150—200	3.6	5.8	*
	200—250	4.2	7.5	*

8. Manual Telegraph Circuits

- (a) For metallic and carrier facilities multiply the 60 speed coefficients by 0.5.
- (b) For all ground return telegraph facilities and loops multiply the 60 speed coefficients by 0.8.



Exhibit 9-B

REPORT ON NEW METHODS OF MEASURING TRANSMISSION
PERFORMANCE ON TELEPRINTER AND DATA CIRCUITS*

Digital Data Simulators

These devices provide a train of pulses which simulate a digital data word which can be fed into the transmitting end of a data transmission system to permit observation of the effect the transmission system has on the pulses or can be inserted at the receiving end of a data transmission system to be compared with pulses which have come in over the system to detect errors.

One company manufactures a family of these devices which provide a pulse train of 30, 60 or 90 bit positions. Switches are provided to cause a pulse to appear in the bit positions desired. Word lengths can be regulated from two bits to 30, 60 or 90 depending on the unit involved. The bit rate is adjustable from 1000 to 500,000 bits/sec. The pulse rise and fall is one microsecond maximum. The pulse amplitude is adjustable over a range of 0 to $\pm 5v$. A clock pulse of $-5v$ is generated at each bit position and a synchronizing pulse of $-5v$ at the beginning or end of each word.

Another company manufactures two such devices which provide a pulse train of 20 or 100 bit positions. Switches are provided to cause a pulse to appear in the bit positions desired. Word length can be regulated from one bit to 20 or 100 depending on the unit involved. The bit rate is adjustable from 10 to 100,000 bits/sec. The pulse rise and fall is one microsecond. The pulse amplitude is $-10v$. A two microsecond clock pulse is provided at each bit position and at the end of each word, outputs can be returned to zero, non-return to zero and audio tone gate.

Pulse Synchronizer

These devices establish a phase lock between a test digital data word being received over a data transmission system and a locally generated digital data word and compares the words to detect errors.

A typical unit operates on words of up to 100 bits in length. The input to the unit from the data transmission unit and the local digital data simulator is a non-return to zero pulse train and data clock. The output is an error pulse to an external error counter (not supplied). It will operate on a data rate of up to 100,000 bits/sec.

These units are used as shown in Fig. 1.

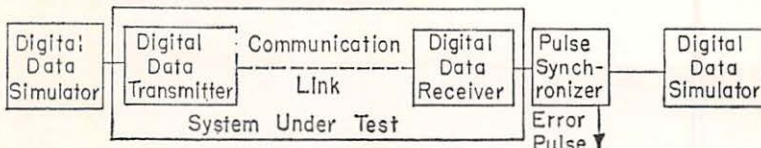


Fig. 1

Data Transmission Test Set

This device includes a transmitter to generate a random digital pattern to be inserted at the transmitting end of a data transmission system, and another similar transmitter, pulse synchronizer and error counter for the receiving end of the system.

* Previous report will be found in 1961 Advance Reports, p. 349.

Exhibit 9-C

DATA TRANSMISSION OVER VOICE CHANNELS

Summary

The transmission of data over channels which have been designed primarily for voice operation presents some new problems to the communications engineer. Certain transmission parameters, which heretofore could be ignored, must now be reviewed carefully in order to assure satisfactory data transmission. It will be the purpose of this report to answer the question; how can good data transmission be provided over existing voice channels? This will involve a review of the transmission parameters affecting data, the mitigation of some of the adverse effects, methods of measuring these adverse effects and a summary of channel characteristics required for some typical types of data terminals.

Introduction

How does data differ from voice?

In ordinary voice transmission over a channel there is a talker and a listener. If the listener cannot hear the talker, he asks him to talk louder. A listener can miss almost half the words said by the talker and still get the sense of the conversation. In other words, almost half of voice conversation is not essential to get the meaning—there is a lot of redundancy. Now, what about a data conversation? Here again there is a talker and a listener in the form of a data transmitter and a data receiver. The great difference between these data sets and the talker and the listener is that they are not intelligent. For want of a better name, they have been called "Electronic Idiots." Why? Because all they know is 0 and 1 and if the 0 or 1 does not arrive at the data receiver reasonably free from distortion (noise, transmission-frequency distortion and delay distortion) and at a proper level, the receiver just will not comprehend what the data transmitter is talking about. This, in simple terms, is the real fundamental difference between data and voice transmission.

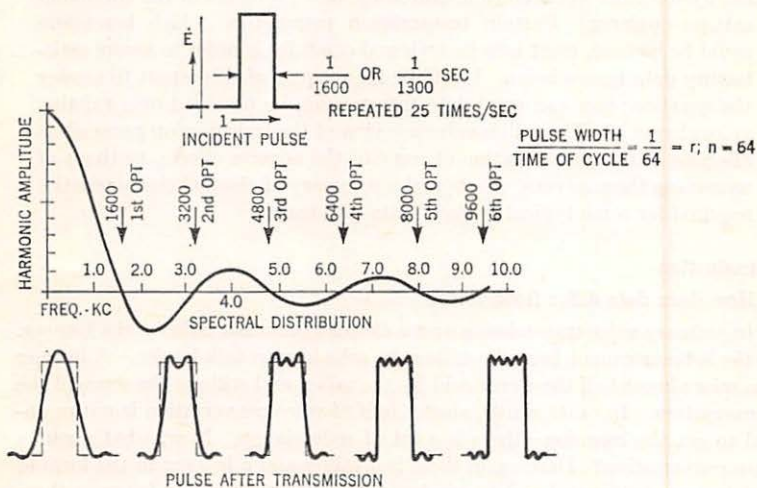
What are the transmission parameters affecting data and what can be done about them?

In order to answer these questions it is necessary to skim over a little bit of pulse transmission theory. The characteristics of a 1600-cycle pulse such as employed in SAGE will be discussed first. This system employs vestigial single side band transmission. Figure 1 shows in detail the effect of adding bandwidth for the transmission of various harmonics up to and including the sixth. In each case shown, a square wave pulse is put in at the transmitting end and the superimposed curve is what appears at the receiving end. It will be noted that transmitting up to and including the second harmonic gives a fair approximation of the input signal. However, a faithful reproduction of the original square pulse will require transmission up to and including the sixth harmonic, i.e., 9000 cycles. Obviously, this would be very costly.

The principal technical requirement which has to be met in the design of a voice channel is that it must transmit the message with a minimum loss of intelligence. Intelligence used here has a broad meaning—it carries with it no

appreciable loss in fidelity. Thus, in the case of acquaintances, the called party on a telephone call, even though 3000 miles away must be able to recognize the calling party's voice.

There are two general items which must be watched carefully to fulfill this requirement: the bandwidth characteristic and noise. The same items must be watched in data channels. However, in the case of data channels, a third characteristic becomes important—delay distortion.



Pulse Transmission Reproduction

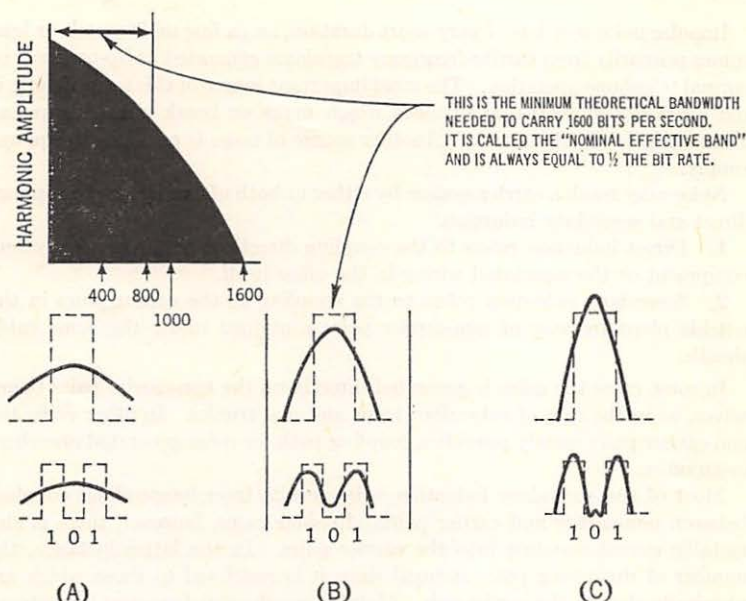
Fig. 1

Bandwidth

Figure 2 is an illustration of the effect of bandwidth on the transmission of a pulse. Here again, use will be made of the SAGE 1600-cycle pulse. If it is assumed, for instance, only a 400-cycle bandwidth is available, the shape of the pulse received at the end of a 400-cycle channel would be as shown in Fig. 2. Thus, if it is desired to send mark-space-mark, or 1, 0, 1, it will be seen from the lower part of Fig. 2A that only a mark or a 1 would be transmitted over the channel. If the bandwidth were increased to 800 cycles as shown on Fig. 2B a mark-space-mark could be transmitted over the channel. It will be noted, however, that the magnitudes of the pulses have been reduced. If the bandwidth is increased to 1600 cycles, Fig. 2C, it can be seen that the original pulses are reasonably well reproduced. It may be concluded then that 1600 cycles is the minimum practicable bandwidth for the transmission of a 1600-cycle pulse using vestigial single sideband transmission. For double sideband approximately 3200 cycles would be required and for frequency shift transmission a little less than 3200 cycles would be required.

It is desirable in the transmitted band for any types of modulation that the transmitted frequencies undergo about the same attenuation. The application of special networks permits this to be accomplished.

The maximum attenuation a data channel can have, neglecting distortion,



Pulse Transmission-Regeneration-Bandwidth

Fig. 2

depends upon the sensitivity of the data receiver. This may vary from about -20 dbm to as great as -50 dbm depending upon the type of data set.

Noise

There are two types of noise present on voice channels; (a) steady or background noise and, (b) impulse noise. One source of steady noise is the hiss noise which originates in amplifiers and modulators of carrier systems. By careful design this is ordinarily kept at a very low level, in the order of -125 dbm.

Another type of background noise is cross modulation noise (interchannel cross talk) which can be present in a disturbed channel when one or more other channels of the same carrier system are energized. It appears because the system has unavoidably small departures from linearity in its amplitude characteristics. This interference is generally manifested in the form of distorted or unintelligible cross talk. It may also be undistorted cross talk.

Since the 130-volt power supply generally contains both voice and carrier frequency noise components, it is a potential source of channel noise. Voice-frequency noise may be induced in the channel wiring of a carrier system on the drop side of a demodulator at a terminal because of inadequate shielding or insufficient separation between channel and power wiring. Most carrier systems have 130-volt supply filters which generally provide adequate control of the carrier-frequency noise.

Signaling tones may be observed on a carrier channel due to the characteristics of the channel filters. In general, improvements in manufacturing processes have reduced this type of noise to a negligible amount.

Impulse noise which is of very short duration, i.e., a few milliseconds or less, comes primarily from carrier-frequency transients generated as by-products of normal telephone operation. The most important source of this type of noise is the operation of relays or switches which make or break circuits carrying alternating or direct currents. Another source of noise is rectifier-type power supply.

Noise may reach a carrier system by either or both of two types of coupling; direct and secondary induction.

1. Direct induction refers to the coupling directly into the carrier system equipment or the associated wiring in the office itself.

2. Secondary induction refers to the coupling to the carrier pairs in the outside plant by way of non-carrier pairs contained under the same cable sheath.

In some cases the noise is generated directly on the non-carrier pairs themselves, as in the case of subscriber loops and dial trunks. In other cases the non-carrier pairs merely provide a coupling path for noise generated elsewhere in an office.

Most of the secondary induction noise results from longitudinal coupling between non-carrier and carrier pairs. In some cases, however, there is also metallic circuit coupling into the carrier pairs. In the latter instance, the number of disturbing pairs is small since it is restricted to those which are physically close to the carrier pair. Metallic coupling is of greatest importance in connection with the operation of data over voice channels in which high level impulse noise may cause errors even though it occurs relatively infrequently.

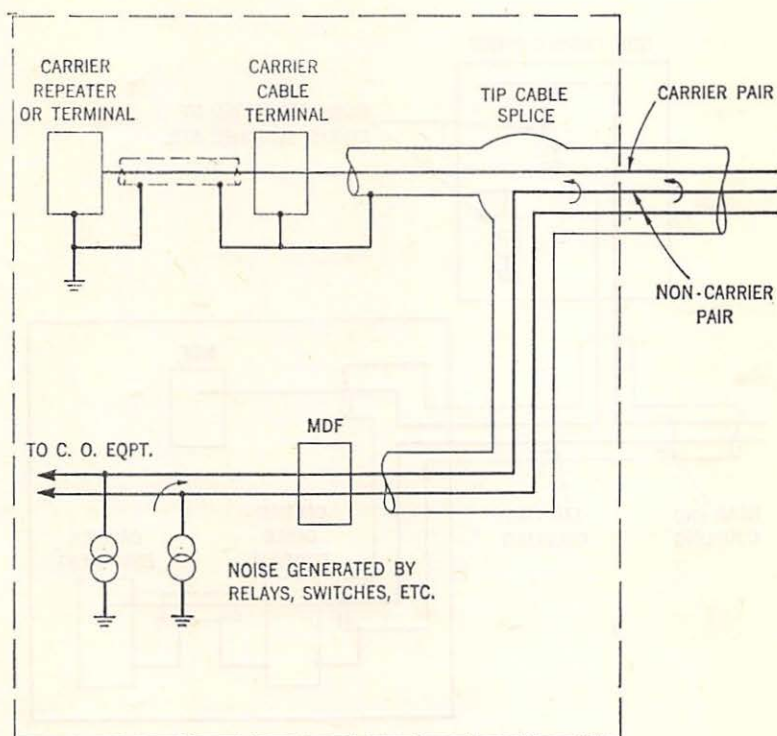
Among the known sources of impulse noise generated in communication plant are:

- (a) Relays and switches in switching offices. (Dial switching offices are usually more prolific of noise than manual switching offices because of the large number of switching operations.)
- (b) D-c telegraph, particularly when operated on grounded simplex facilities.
- (c) Breakdown test sets, buzzer-type sets and 4-cycle test current.
- (d) Rectifier-type power supply.
- (e) 20-cycle ringing.

Figure 3 illustrates how noise generated by relays and switches in the office may travel into the plant over the longitudinal (ground return) circuit, there energizing the longitudinal circuit of the carrier pairs by near-end coupling. Due to the less-than-perfect longitudinal-to-metallic balance of the carrier pair and the associated equipment some of the noise power appears in the metallic circuit of the carrier system.

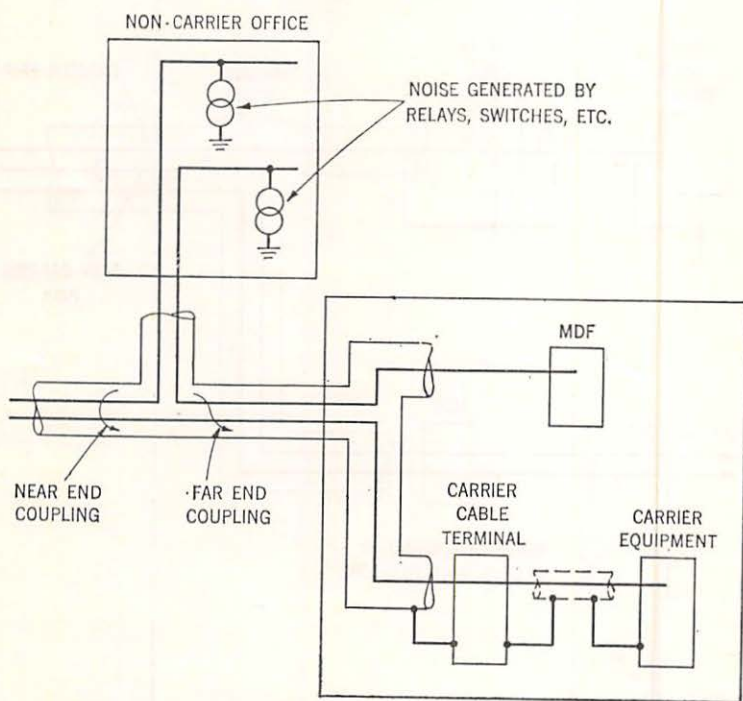
Figure 4 shows how noise generated by central office equipment which is not located in the same building as the carrier equipment can nevertheless appear on the carrier system. It will be noted that noise can reach the carrier pairs by way of both near-end and far-end coupling.

The most important path for induction from sources external to the communication plant is by secondary induction from non-carrier pairs. These include voice-frequency channels in the carrier cable having extensions directly into open wire lines, or to branch cables of short length connected to open wire



Secondary Induction Paths

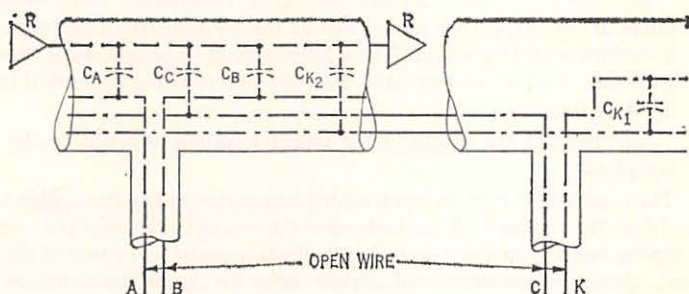
Fig. 3



Noise Induction from Non-Carrier Office

Fig. 4

or drop wire plant as shown in Fig. 5. A longitudinal voltage is picked up on the open wire or drop wire from an external source such as atmospheric static, a radio transmitter or another carrier system. This voltage is propagated longitudinally into the cable pairs connected to the open wire and then into the carrier system by the same process of longitudinal coupling and unbalance as discussed above.



R = N OR ON CARRIER REPEATER OR TERMINAL.

A OR B OR C OR K = OPEN OR DROP WIRE EXTENSION OF OTHER CABLE PAIRS.

C_A , C_B , C_C , C_{K1} , C_{K2} = LONGITUDINAL CIRCUIT COUPLINGS BETWEEN CABLE PAIRS SHOWN.

Induction from External Sources

Fig. 5

Induction from other carrier systems may occur as a result of metallic circuit or longitudinal circuit couplings. The interfering carrier systems may contain unwanted frequencies in addition to components in their assigned frequency band.

When a carrier system is operated in part or entirely over cable pairs with non-soldered twisted joints erratic noise of various kinds may be apparent as a result of the variation in resistance of such joints with movement of the conductors due to changes in temperature or wind action. The use of punched sleeves or soldering on carrier pairs should maintain uniformly low resistance over a long period of time.

The impulse noise created by atmospheric static may reach the carrier system by either or both of two paths: through the cable sheath or by way of open wire pairs or drops which tap into the carrier cable. The first of these is generally of importance only where systems several hundred miles long are operated in small size cables. The second path is much more critical and even short systems may require the application of suppression measures as discussed below.

Secondary induction of office noise may be controlled as follows:

(a) Plan the carrier system layout so the repeaters or terminals are physically separated from the source of the noise. In this way the noise is attenuated before reaching the carrier system. To a large extent this attenuation is due to the loss in the longitudinal circuit of the disturbing conductors. Although it is not possible to estimate longitudinal loss precisely, it may be approximated by using metallic circuit attenuation data.

(b) Use a separate carrier-only entrance cable. Here the noise is at-

tenuated both as it travels over the non-carrier pairs from the office to the junction with the carrier cable and from this point back to the office over the carrier pairs. The noise reduction is, therefore, roughly twice the one-way loss in the cable pairs.

(c) Install Western Electric 230 and 231-type, or equivalent longitudinal suppression inductors on the non-carrier pairs.

(d) Install Western Electric 126-A, or equivalent, radio suppression filters in the non-carrier cable pairs at the main distributing frame of the disturbing switching office. These filters should be placed on all non-carrier pairs that enter the carrier cable, with the output wiring segregated from the input wiring.

(e) Restrict the length of the repeater section adjacent to the carrier equipment.

The carrier-frequency noise on cable plant varies widely from cable to cable and from time to time. It depends upon the amount of noise at the source, the coupling loss and frequently the longitudinal-to-metallic balance of the carrier line. Actual measurements of impulse noise on the carrier pairs are highly desirable and measurements should be used wherever possible.

Generally it is advisable to suppress noise from d-c telegraph at its source. If it is known that grounded telegraph is the sole source of impulse noise in a repeater section, the following measures will probably be adequate.

The highest telegraph noise from grounded d-c telegraph may be expected from repeaters whose transmitting relay contacts operate directly into the line. Any high impedance between the relay contacts and the line, such as a relay winding, retard coil of a voice-frequency noise killer, or resistance pads, and any low impedance shunts to ground, such as the capacitor in some of the noise killer circuits, provide important reductions in the amount of carrier-frequency noise put out on the line. Objectionable interference may be obtained from the operation of receiving relays. This is due to the relatively low coupling loss between the operating contacts and the windings of the relay which are connected in the line circuit. In some telegraph repeaters, the noise suppressor is not effective in reducing carrier-frequency noise when receiving or transmitting when a loop applique circuit is used with the repeater.

Where it is necessary to maintain grounded telegraph operation under the same sheath as the carrier pairs, the telegraph repeaters should be equipped with voice-frequency noise killers wherever they are available. Not all of the standard arrangements are effective in the carrier-frequency range and sometimes the filters are bypassed by the wiring capacitance. In order to afford carrier-frequency suppression, therefore, a 0.5 mf capacitor should be connected from the simplex leg to ground.

Where a "neutralizing wire" (occasionally used to minimize the effect of earth potentials, crossfire, or power induction) is operated through relay windings via another simplex it should be treated as another telegraph circuit and 0.5 mf close limit capacitors to ground should be applied at each end.

Western Electric 1530A and 1530B inductors or their equivalent are available for wideband suppression of longitudinal noise which enters a carrier cable or cable extension at open wire or drop wire taps. The inductors have similar electrical characteristics and differ primarily in the number of windings, the 1530A having two windings and the 1530B having four windings.

The need for the two types of coils and their respective applications may be summarized as follows:

(a) Longitudinal noise on an open wire line exists not only in the circuit formed by a pair with its ground return but also in the phantom and ghost circuits existing between the various combinations of pairs and their ground returns. When an open wire group is phantom transposed the noise on that phantom circuit is appreciably reduced although the noise on the "spurious" phantoms (between the group and other pairs on the line) remains high. In order to be effective these spurious phantoms should be suppressed.

(b) Neither the 2- nor the 4-winding coil has any appreciable effect on equal currents flowing in opposite directions over the two conductors of a pair; i.e., that both types of coils tend to be transparent to the metallic circuit.

(c) The most effective suppression is afforded by the 2-winding coil which always presents a high impedance to equal currents flowing in the same direction in the two conductors of a pair. Since this is the condition with a derived phantom circuit the attenuation of the phantom even in the voice-frequency range may be as high as 15-20 db.

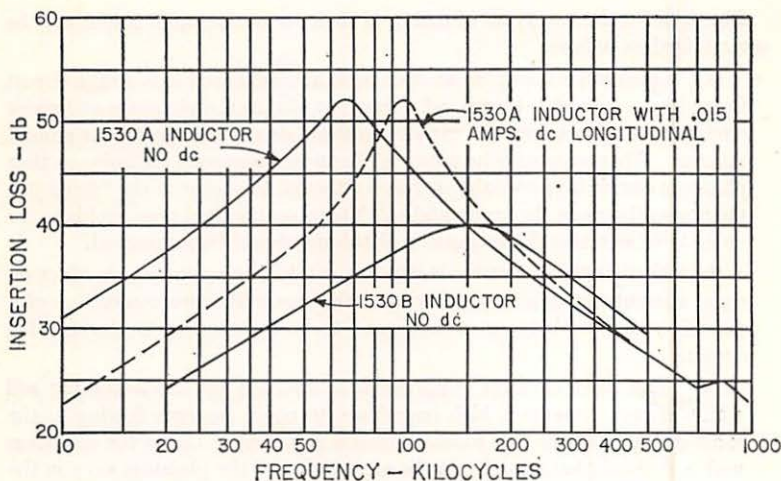
(d) The 4-winding coil presents a high impedance to equal currents flowing in the same direction in the four conductors of a quad or phantom group, but has little effect on equal currents flowing in the same direction on one side circuit and flowing in the opposite direction on the other side circuit.

(e) The amount of suppression introduced by a 4-winding coil inserted between an unphantomed open wire group and a quad in the cable is appreciably less than with 2-winding coils because the phantom circuit is unsuppressed. With non-quadded cable the 4-winding arrangement is even less effective due to the physical separation of the two pairs in the cable.

The insertion loss of 1530-type inductors depends upon the impedance of the circuit in which they are inserted and on the longitudinal d-c in the windings. When properly installed it is expected that they will afford about 25-30 db of suppression over the in-band and image frequency ranges of the cable carrier system. Figure 6 shows the measured insertion loss of a 1530A 2-winding inductor in a 360-ohm circuit, which approximates the conditions under which the inductor is generally used. This figure also shows how the suppression loss is affected by a longitudinal current of 15 milliamperes. This simulates the condition where 48-volt toll grade battery is used in tip-party message service with a 1000-ohm ringer connected to ground. Higher longitudinal current will shift the insertion loss characteristic farther toward the high-frequency end of the scale. Figure 6 shows also the characteristics of the 1530B inductor for which the longitudinal insertion loss is slightly less than that of the 1530A. Balanced d-c in the metallic circuit of either inductor has a negligible effect on the suppression loss.

The voice-frequency loss of these inductors when properly installed in a 600-ohm metallic circuit is a fraction of a db. At higher frequencies the metallic circuit loss increases and is above 5 db in the 40-260 kilocycle frequency range.

The 1530-type inductors must be protected from damage due to transient surges by protector blocks which form a part of the inductor assembly. If installed where open wire or drops are brought into the cable through existing



Longitudinal Insertion Loss of 1530-Type Inductors

Fig. 6

protector mountings, it is necessary that the protector blocks in the latter be omitted.

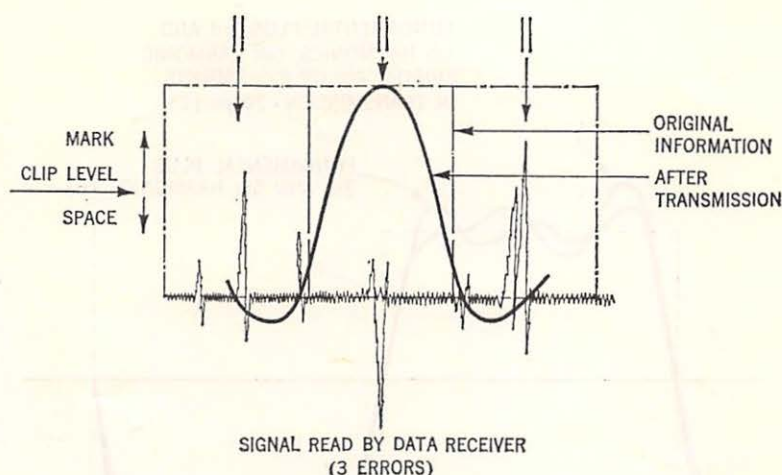
Mention has already been made of the Western Electric 230 and 231-type longitudinal inductors. These inductors are available under four codes as follows:

Code	No. of Windings	Mounting
230P	4	(Unpotted—Mount in apparatus cases.)
230R	2	
231M	4	(Relay rack mounting)
231N	2	

The toroidal cores used in the four inductors are the same and the electrical characteristics of the unpotted units are identical to those which are cased for relay rack mounting. The considerations which determine the selection of 2- or 4-winding coils are similar to those applying to the 1530-type inductors. Accordingly, the 2-winding inductors should be provided in all cases except where phantom circuits are used. When 4-winding 230P inductors have been spliced up to quadded cable and the sides of the quads are used for physical circuits, the maximum suppression will not be realized unless these circuits are wired through 2-winding relay rack mounted inductors (231N). The insertion loss of these inductors is peaked in the neighborhood of 200 kc and the loss at higher and at lower frequencies drops off more rapidly than with the 1530-type.

Figure 7 shows the effect of impulse noise on data transmission. Here there is a single pulse of 1600 cycles. If during transmission, three short pulses of noise occur a total of three errors will be produced. In other words, a mark sent will result in two marks and one space received.

Steady or background noise can be measured using the Western Electric 2B or 3A Noise Measuring Set. Impulse noise can be measured using either of these two sets along with a General Radio 1556A or 1556B Impact Meter.



The Noise Problem

Fig. 7

Delay Distortion

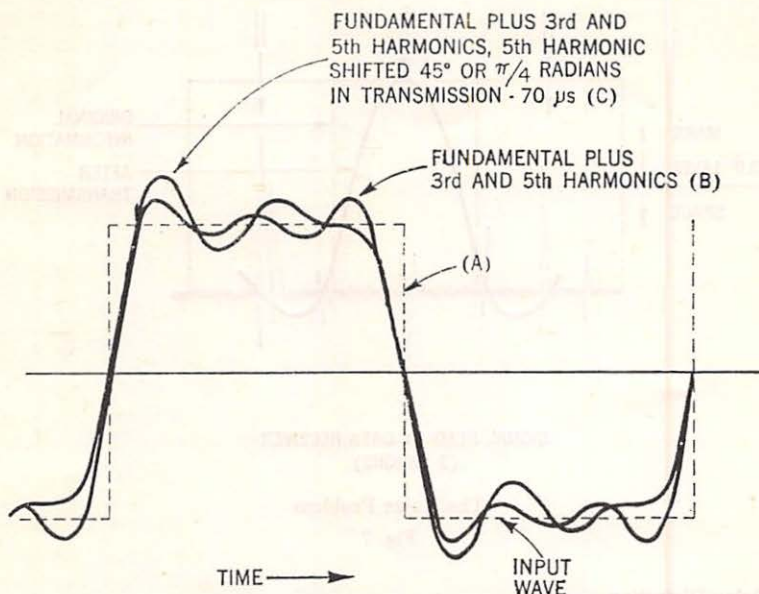
Ideally, a good voice channel should have the capability of transmitting all frequencies within the 300 to 3000-cycle range at the same speed—the delay must be the same. Where the delay is not the same at all frequencies within this range, it is distorted. Hence, the term delay distortion. Practically considerable latitude with respect to delay can be taken and still not affect the speech intelligibility to any great extent. This is due primarily to the characteristics of the human ear and brain. The ear is essentially a slow-acting device. In order for it to recognize a sound, that sound must persist in the order of 0.2 second.

Even if the ear misses a number of syllables, or even words for that matter, the brain can step in and pick up the slack—it can anticipate what is coming and so fill in the gaps. Thus, if somebody says, “you owe me \$500,” about all one needs to hear are the words “you owe.” Your brain can fill in the rest.

Another factor which makes delay distortion in voice transmission relatively unimportant is the slow equivalent bit rate of speech. Studies show that the information content of speech is equivalent to only about 40 bits per second.

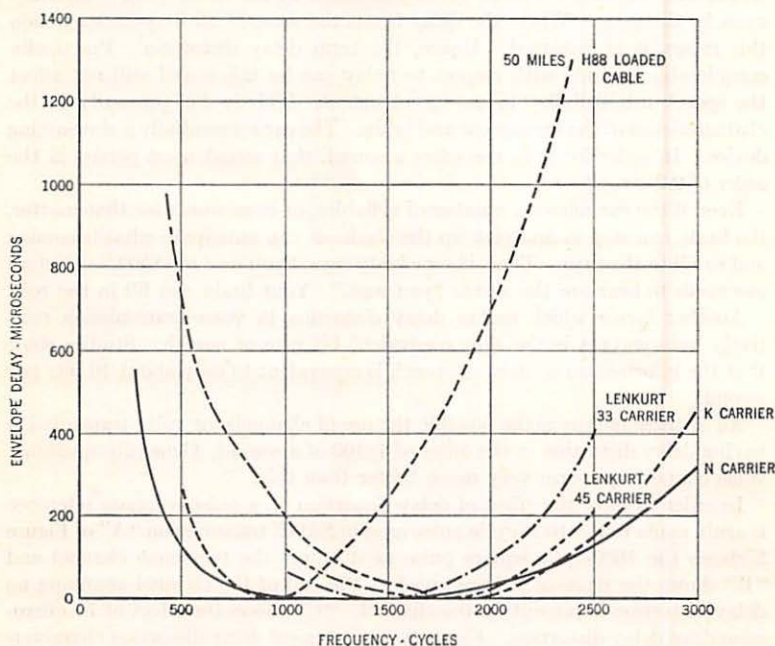
All of these factors make possible the use of channels for voice transmission having delay distortion in the order of 1/100 of a second. Generally speaking, voice channels perform very much better than this.

In order to show the effect of delay distortion on a pulse, suppose reference is again made to the 1600-cycle pulse used in SAGE transmission “A” of Figure 8 shows the 1600-cycle square pulse as it enters the telephone channel and “B” shows the pulse as it is received at the end of the channel assuming no delay distortion is present on the channel. “C” shows the effect of 75 microseconds of delay distortion. Figure 9 shows typical delay distortion characteristics of various types of carrier channels and a loaded cable circuit. It will be noted that the distortion is very much greater at the extreme ends of the



Effect of Delay Distortion

Fig. 8



Envelope Delay of Various Facilities

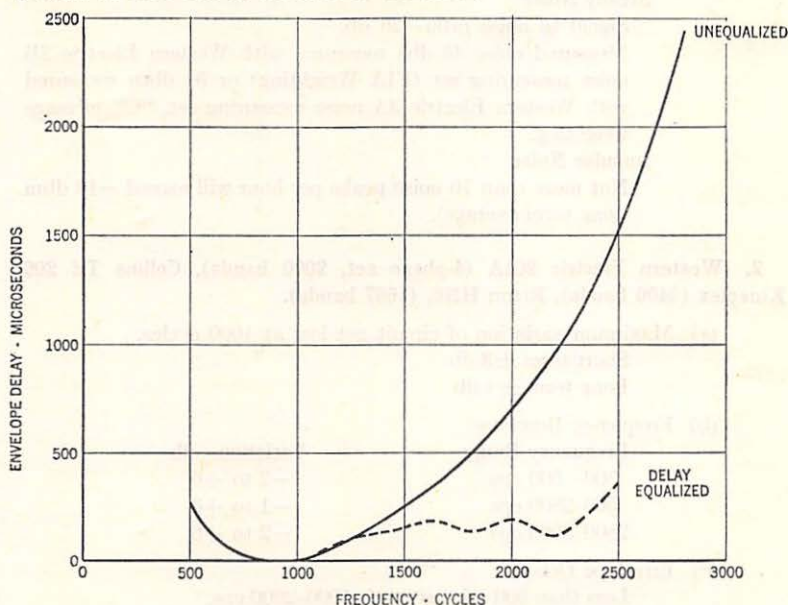
Fig. 9

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pass band. Again by the proper application of special networks this can be flattened out. Figure 9A shows the delay distortion characteristics of a 50-mile 19 H88 loaded cable circuit before and after equalization is applied.

Error Rate

Error rate on a data channel depends on the relative amounts of the various types of distortion already discussed. On a channel which is relatively free of these types of distortion an error rate in the order of one in 10^6 to 10^7 is not uncommon. Certainly most voice channels used for data transmission should provide an error rate in the order of one in 10^5 .



Envelope Delay of 50 Miles of H88 Loaded Cable

Fig. 9A

Channel Characteristics Required for Various Types of Data Sets

Listed below are the channel characteristics required for the various types of data sets made by the Western Electric Company as well as other manufacturers. For all types of channels listed below it is assumed that the nominal impedance of the channel is 600 ohms resistive. Short term variations are assumed to be those variations which take place during a very short period such as a few minutes. Long term variations are those which occur during a period extending a day or more. The over-all net loss for all types of channels is assumed to be 8 ± 1 db at 1000 cycles.

1. Western Electric 202A (FM Set—1200 Bauds), Automatic Electric AE202A (FM Set—1200 Bauds).

(a) Maximum variation of circuit net loss at 1000 cycles.

Short term ± 3 db

Long term ± 4 db

(b) Frequency Response

Frequency Range	Variation—db
300–1000 cps	–2 to +6
1000–2400 cps	–1 to +3
2400–2700 cps	–2 to +6

(c) Envelope Delay

Less than 1000 microseconds over band from 1000 to 2400 cps.

(d) Noise Characteristics

Steady Noise

Signal to noise ratio –26 db.

Measured noise 48 dba measured with Western Electric 2B noise measuring set (F1A Weighting) or 54 dbrn measured with Western Electric 3A noise measuring set, “C” message weighting.

Impulse Noise

Not more than 70 noise peaks per hour will exceed –18 dbm (long term average).

2. Western Electric 201A (4-phase set, 2000 bauds), Collins TE 206 Kineplex (2400 bauds), Rixon HN6, (1667 bauds).

(a) Maximum variation of circuit net loss at 1000 cycles.

Short term ± 3 db

Long term ± 4 db

(b) Frequency Response

Frequency Range	Variation—db
300– 500 cps	–2 to +6
500–2800 cps	–1 to +3
2800–3000 cps	–2 to +6

(c) Envelope Delay

Less than 500 microseconds 1000–2600 cps.

Less than 1500 microseconds 600–2600 cps.

Less than 3000 microseconds 500–2800 cps.

(d) Noise Characteristics

Steady Noise

Signal-to-noise ratio –26 db.

Measured Noise 48 dba measured with Western Electric 2B noise measuring set, F1A weighting or 54 dbrn measured with Western Electric 3A noise measuring set “C” message weighting.

Impulse Noise

Not more than 70 noise peaks per hour will exceed –22 dbm (long term average).

3. Western Electric 201A modified (4-phase set—2400 bauds) Rixon HN6, (2500 bauds)

(a) Maximum variation of circuit net loss at 1000 cycles

Short term ± 3 db

Long term ± 4 db

(b) Frequency Response

Frequency Range	Variation—db
300–500 cps	–2 to +6
500–3000 cps	–1 to +3
3000–3200 cps	–2 to +6

(c) Envelope Delay

Less than 300 microseconds 1000–2600 cps.
Less than 500 microseconds 800–2800 cps.
Less than 1500 microseconds 600–3000 cps.
Less than 3000 microseconds 500–3000 cps.

(d) Noise Characteristics

Steady Noise

Signal-to-noise ratio –26 db.

Measured noise 48 dba measured with Western Electric 2B noise measuring set F1A weighting or 54 dbrn measured with Western Electric 3A noise measuring set, “C” message weighting.

Impulse Noise

Not more than 70 noise peaks per hour will exceed –22 dbm (long term average).

4. Western Electric A1 Digital Data System

(a) Maximum variation of circuit net loss

Short term ± 1 db
Long term ± 4 db

(b) Frequency Response

Frequency Range	Variation—db
500–1000 cps	± 3
1000–2600 cps	± 2

(c) Envelope Delay

Less than 500 microseconds 1000–2500 cps.

(d) Noise Characteristics

Steady Noise

Signal-to-noise ratio –26 db.

Measured noise 48 dba measured with Western Electric 2B noise measuring set F1A weighting or 54 dbrn measured with Western Electric 3A noise measuring set, “C” message weighting.

Impulse Noise

Not more than 70 noise peaks per hour will exceed –28 dbm (Long term average).

Appendix A

Measurement of Impulse Noise on Channels Used for Data Transmission

General

This appendix deals with the measurement of impulse noise on channels used for the transmission of data. The objectives are specified in terms of the peak voltages measured under specific conditions. Accurate readings can be obtained only with a much faster acting meter than is available in the Western Electric 2-type or 3A Noise Measuring Set.

The most satisfactory meter now available is the 1556A or 1556B Impact-Noise Analyzer manufactured by the General Radio Company. It is described below.

Noise Magnitude as a Function of the Measuring Device

The measured effective or rms voltage of a single frequency signal is independent of the bandwidth of the meter employed. That is to say, the same readings will be obtained on a voltmeter having a flat response over a wide frequency band and on a narrow band selective frequency voltmeter. However, when the signal under measurement comprises a wide range of frequencies the meter readings will be different and the meter having the wider frequency response will read higher. Thus when measuring thermal noise, for example, the rms voltage increases by 3 db when the bandwidth of the meter is doubled.

When measuring the peak voltage of a single frequency signal the meter reading is again independent of the bandwidth of the meter. The peak voltage of a sine wave bears a fixed relation to its rms voltage (peak volts = 1.41 by rms volts). If the signal being measured comprises a wide range of frequencies the meter reading is even more sensitive to bandwidth than when measuring the effective voltage. With impulse noise, for example, the peak voltage increases about 6 db when the bandwidth is doubled.

The noise on a channel used for data transmission seldom consists of a single frequency or pure sine wave. Generally, it is quite complex and varies in a random manner both as to magnitude and frequency. The occurrence of data transmission errors is closely related to the occurrence of the random noise peaks. In order to obtain an adequate correlation between the noise and the error rate it is necessary to use a meter which operates fast enough to indicate the true peak voltage, and also to specify its bandwidth.

Measurements are of value only if they are taken during a period when the highest noise peaks are likely to occur. If a data circuit operates over a radio channel on which the noise peaks may result from modulation, the interference is likely to be greatest when the traffic load is highest. If part of the load on the radio channel consists of other data circuits, they will probably constitute a major source of modulation noise, and the noise should be measured while they are in use. If the facility under test is a cable carrier channel, the noise will probably be highest when there is the greatest switch and relay activity in the offices at which the carrier terminals and repeaters are located. Thus, in the case of these cable carrier channels, it is important to measure the noise during the busy hour of these offices. On open wire carriers the noise would be expected to be greatest during thunderstorms.

As peak noise varies over a wide range of amplitudes, it follows that a short period of observation can be used only at the sacrifice of accuracy. If noise is observed for only a few minutes it is quite possible that the resulting measurements will not indicate the true noise picture and will, therefore, lose their value. In general, the testing period should last at least one-half hour.

Exhibit 9-D

IMPULSE NOISE—SOURCES AND EFFECTS*

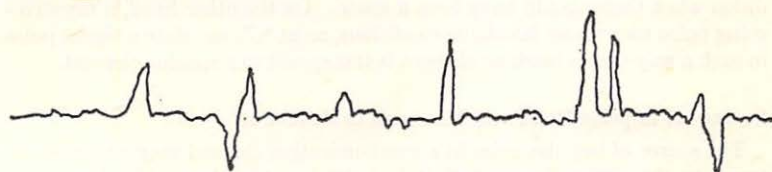
Types of Noise

In all forms of electrical communication the objective is to transmit the greatest amount of intelligence possible consistent with maintaining a high degree of reliability. It is universally true that, regardless of the type of information being transmitted, the chief limitations to communications efficiency are imposed by noise.¹ Modern communication technique is therefore a continuous fight to overcome restrictions imposed by noise either by developing systems that are more immune to its effects or by devising means to reduce its magnitude.

Noise in a communications facility can appear in a variety of ways.² In fact, any extraneous or unwanted signal introduced into the channel may be considered as noise although general usage confines the application of the term to unintelligible interfering signals. Depending on the sources from which they are derived, the interfering signals may take many forms such as power hum, hash, babble, whistles, clicks, thumps and many others which are all too familiar. Generally speaking, the various kinds of noise fall into two broad classifications, one in which the noise is continuous—known as white noise—and the other in which it is intermittent or spasmodic. It is this latter class of noise, usually called impulse noise, with which the following discussion is concerned.

Impulse Noise

Impulse noise, as indicated by its name, is pulsed in nature. It is a relatively high level burst of energy of short duration, usually lasting from a few microseconds to tenths of a second. The pulses occur randomly and may either be grouped or separated by long intervals. In contrast to white noise the ratio between the peak energy of the individual pulse and the average energy of the impulse noise is very large. For this reason conventional noise measuring sets are unsatisfactory in assessing impulse noise and special techniques for measuring it have had to be developed. Quite often noise measuring sets may show a favorable signal-to-noise ratio and yet the communication channel may be quite unusable for high speed data transmission because of the presence of impulse noise.³ A typical oscillograph trace in which impulse noise predominates is shown in Fig. 1.



Trace of Noise Signal in Which Impulse Noise Predominates

Fig. 1

* Numerical references are listed on page 184.

Effects of Impulse Noise

The role of impulse noise and the necessity of controlling it has only recently become apparent with the development of higher speed telegraph and data transmission systems. In voice, program and similar types of transmission a pulse lasting a few milliseconds, even of high intensity, is practically unnoticeable and certainly will not destroy the intelligibility because of the slowly varying character and the high degree of redundancy of speech. Similarly, in slow speed telegraph and other such signaling systems the elements of intelligence are several orders of magnitude in time greater than the pulses of noise, making the probability of altering an element sufficiently to cause an erroneous interpretation of it in the detecting device quite low.

With higher speed digital signals, however, the duration of the element of intelligence is of the same order as, or even shorter than, the noise pulse giving impulse noise a significant effect.

Since the duration of the signaling element, which is the inverse of transmission speed in bits per second, is vital in considering impulse noise, it will be useful to consider this parameter. The duration of signaling element for typical classes of transmission is given in Table 1.

Table 1

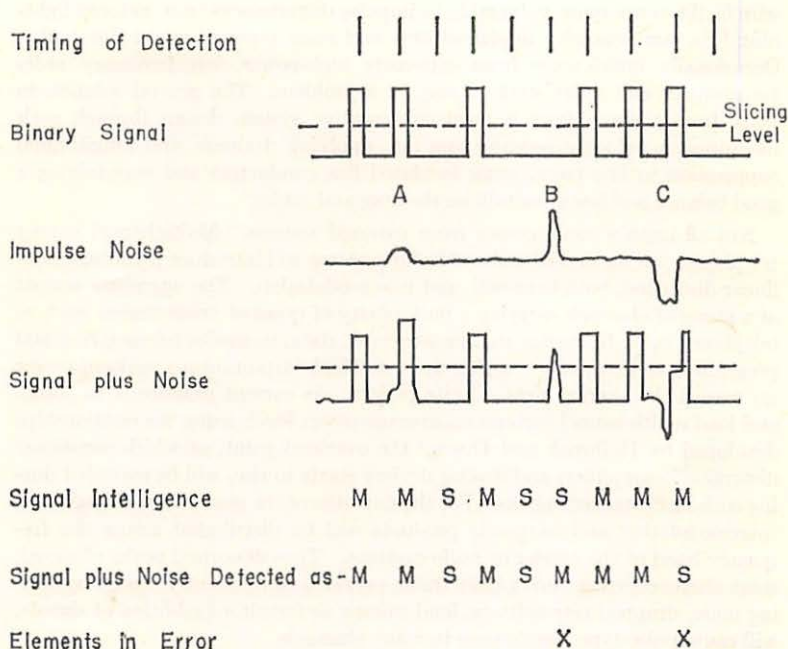
Transmission Speed	Duration of Signaling Element (Seconds)
60 words per minute	0.022
100 words per minute	0.0132
200 bauds	0.005
600 bits per second	0.00167
2 400 bits per second	0.00042
10 000 bits per second	0.0001
62 500 bits per second	0.000016

Experience has shown that at any speed above 100 words a minute, or 75 bauds, noise peaks of the same duration as the signaling pulses will frequently occur and hence impulse noise must be dealt with.

The reason why impulse noise causes errors in a higher speed digital transmission may best be shown diagrammatically as is done in Fig. 2. At 'A' a positive-going noise pulse adds to the positive signal pulse to produce a greater positive pulse which is still correctly detected. However, at 'B' a spacing element is filled in by the noise pulse resulting in the detection of a marking condition when there should have been a space. On the other hand, a negative-going pulse may under favorable conditions, as at 'C', mutilate a signal pulse in such a way that a marking element is transposed to a spacing element.

Sources of Impulse Noise and Measures to Reduce It

The source of impulse noise in a communication channel may either be external to the system from which it is derived or may be within the system itself. The noise from external sources is introduced through induction from neighboring circuits or devices in which there are abrupt changes in current or voltage or steep-fronted transients. The worst offenders for generating impulse noise are the circuits containing inductance in which the currents are



How Impulses Introduce Errors in Data Transmission

Fig. 2

suddenly interrupted, such as relay circuits. Automatic telephone exchanges, telegraph switching apparatus, telegraph repeaters, signaling panels associated with telephone carrier systems and control circuitry of various kinds are the most frequently encountered sources within an office. Varying contact resistance in relays, jacks, poorly soldered joints and protectors is also a factor.

Care and attention to small points are generally required in dealing with sources inside an office. Spark suppression and wave-shaping can be used in relay circuits to reduce the intensity of the transient currents and voltages in the interfering circuits. Then, coupling between the data circuit and the interfering circuit can be reduced by making the physical separation large, separating the wiring associated with the two types of circuits, shielding all low level portions of data circuits and reducing the power supply impedance common to the apparatus assigned to both classes of circuits over as wide a frequency range as possible.

The line portions of circuits as well as the portions in the offices offer great potentialities for inducing impulse noise. Grounded telegraph circuits and dialing circuits in the same cables as the data circuit are particular offenders for which the remedial action is usually spark-suppression, wave-shaping and the use of balanced circuits. In the most severe cases the use of exchange cables must be avoided, it then being necessary to provide for data circuits in toll cables or even to erect special cables. As may be expected, circuits on open

wire facilities are quite vulnerable to impulse disturbances from induced lightning hits, contacts with foreign objects and some types of power line faults. Occasionally interference from extremely high-power, low frequency radio transmitters and radar stations may be a problem. The general solution to noise from these sources is good conservative system design through such measures as reducing repeater spacing, applying drainage and longitudinal suppression to line pairs, using insulated line conductors and maintaining a good balance and low cross talk on the lines and cables.

Not all impulse noise comes from external sources. Multichannel carrier telephone systems and broadband radio systems will introduce it through non-linear distortion, both harmonic and intermodulation. The aggregate output of a group of channels carrying a multiplicity of types of transmission such as telephone, voice frequency carrier telegraph, data, facsimile, telemetering and program in an extremely complex wave in which instantaneous peaks of power far exceed the average over a finite period. As current practice is to design and load multichannel systems on average power levels using the relationships developed by Holbrook and Dixon,⁴ the overload point, at which non-linear distortion in amplifiers and similar devices starts to rise, will be exceeded during such instantaneous peaks. For the duration of the peak, short though it is, intermodulation and harmonic products will be distributed across the frequency band of the carrier or radio systems. Thus abnormal peaks of signal, most often occurring during busy traffic periods and frequently caused by dialing noise, dropped transmitters, loud talking or fortuitous addition of signals, will cause pulse-type interference in many channels.

Several approaches may be taken to the solution of impulse noise introduced into a wideband system by non-linear distortion. The peaks may be controlled by:

1. Reducing the reference transmission level on the channels not carrying data,
2. Reducing the number of channels assigned to the system, particularly those carrying traffic with a heavy loading characteristic, and
3. Applying peak limiters to the channels.

Immunity to interfering peaks may be increased by raising the reference transmission level of the data circuits to gain margin over the noise pulses. To a certain extent, however, this approach is self-defeating as the system loading is increased, enhancing the likelihood of exceeding the overload point.

Reducing Effects of Impulse Noise

Once impulse noise is introduced into the data channel can anything be done to mitigate its effects? A tremendous amount of effort in the last few years has been directed toward improving the performance of data transmission systems in an environment of this type of noise. The first and most straightforward is to reduce envelope delay distortion, attenuation distortion and carrier shifts as these types of distortion measurably contribute to the mutilation of data pulses by impulse noise. Another approach is to select a type of modulation for the line signal that has greater immunity to noise. Early data transmission systems used double sideband amplitude modulation to be followed by vestigial sideband amplitude modulation in order to obtain a higher speed within a given bandwidth.^{3, 6} Largely because of superior performance

in the presence of noise, amplitude modulation has been succeeded by frequency modulation ^{7, 8, 9} and even more recently by phase modulation. Other more sophisticated systems, such as predicted wave ⁵ have been developed, which it is hoped will give more favorable results in the fundamental conflict of noise and speed of transmission.

There is yet another powerful tool that may be used to overcome the effects of pulse-mutilation by impulse noise; namely, error detection and error correction schemes. As this is a broad expanding and complex field no attempt will be made to review current practices or the results that may be expected. It will suffice to say that if any error control system is to be useful in combating impulse noise, it must be capable of dealing with both single element mutilations and multiple element mutilations occurring during bursts of impulse noise. The present state of studies to determine the effectiveness of the various parameters in relation to the amount of redundancy or waste introduced, shows clearly that no simple answer exists. The statistical character of the errors introduced in each situation will largely dictate the methods of applying various forms of parity such as horizontal, vertical or diagonal, simple or multiplex interlace and specially designed codes to get the greatest possible efficiency of transmission. ^{10, 11, 12, 13, 14}

Measuring Impulse Noise

In the majority of types of communication, such as telephone, steady state or white noise causes the most disturbing effects. A considerable amount of technique and instrumentation has been developed to measure and assess the effects of white noise. ^{15, 16} Because of their relatively large time constants these meters cannot be used for measuring impulse noise.

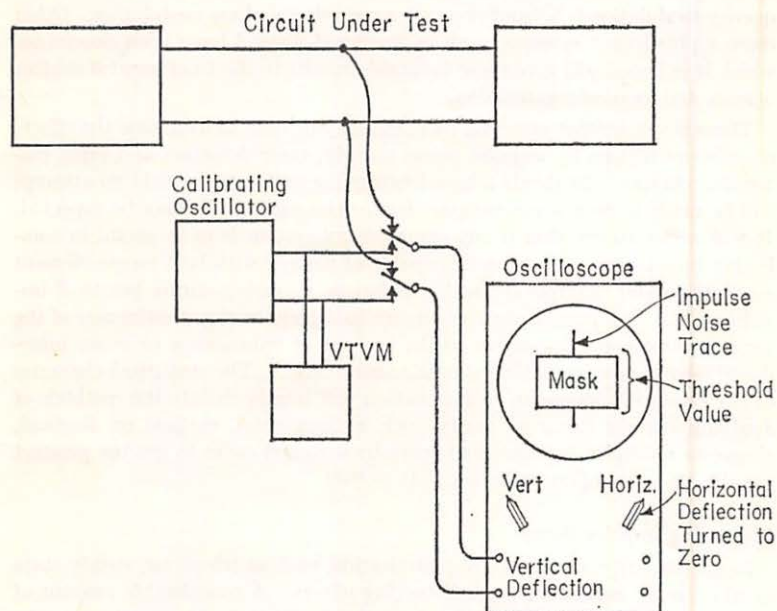
The first methods developed for measuring impulse noise were simple but laborious. Basically they involved the following steps and an arrangement of equipment as shown in Fig. 3:

1. Calibrating an oscilloscope with a vacuum-tube voltmeter to mark the threshold amplitude above which pulses will be counted.
2. Bridging the oscilloscope across the circuit to be tested.
3. Counting the number of pulses exceeding the threshold amplitude in a given length of time. The most convenient arrangement is to reduce the horizontal deflection of the oscilloscope to zero and to mask the face of the oscilloscope to hide pulses below the threshold.

More recently the basic method has been refined with the use of Impact Noise Analyzers. ¹⁷

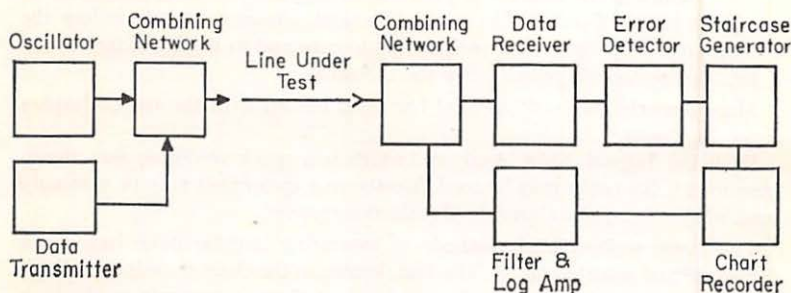
With the Impact Noise Analyzer, which is a quick response, slow decay instrument, the peaks may be read directly on a meter that may be manually reset whenever a pulse above the threshold is received.

Two more sophisticated methods of measuring impulse noise have been developed and reported on. ¹⁸ The first, known as the chart recording method, records impulse noise peaks and errors against time on separate tracks thus permitting a correlation of the two. The block diagram of the apparatus used in this method is given in Fig. 4. The companion method, designated Telephone Impulse Noise Analyzer Method (TINA), records the peak amplitude, pulse width, time and number of pulses in the chain. A block diagram of the apparatus is given in Fig. 5.



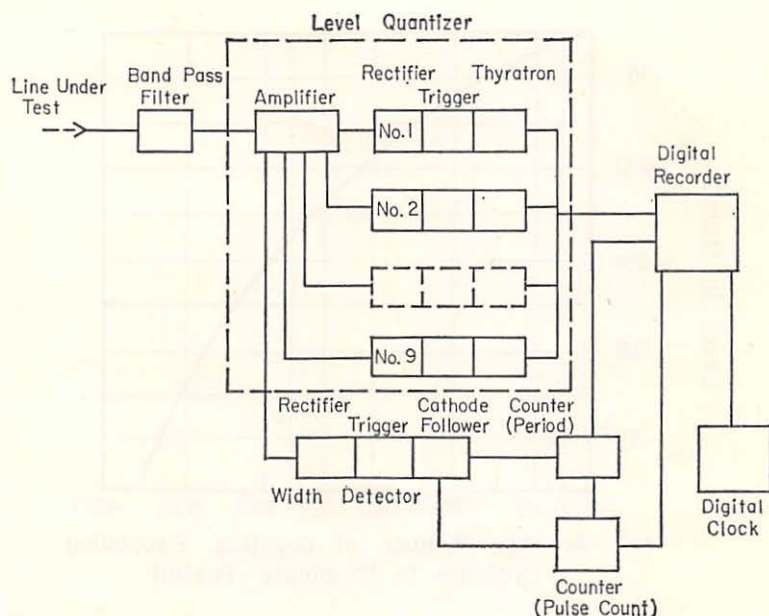
Measuring Impulse Noise
Oscilloscope Method

Fig. 3



Measuring Impulse Noise
Chart Recorder Method

Fig. 4



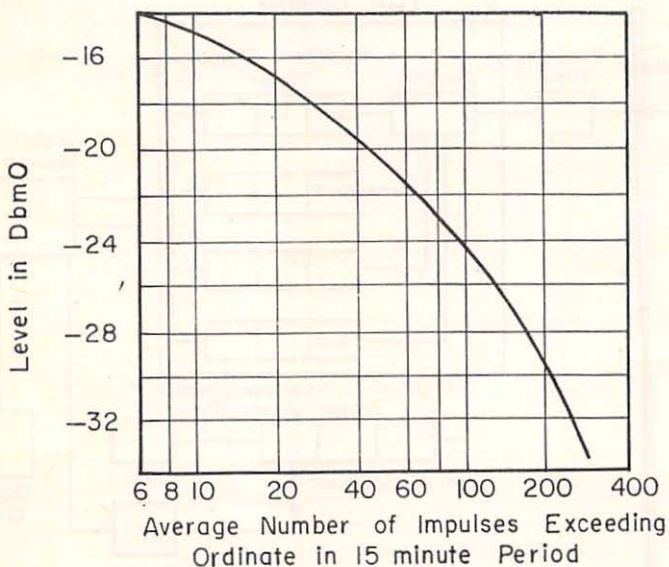
Measuring Impulse Noise
Telephone Impulse Noise
Analyzer (TINA) Method

Fig. 5

Experimental Results

Rather little information has been published on the impulse noise that may be expected on telephone circuits or on the direct correlation of impulse noise and errors in transmission.^{18, 19, 20} If impulse noise, aided by delay distortion, amplitude distortion, frequency shifts, etc., may be considered as the dominant cause of errors in an actual system,—that is, a close correlation exists between errors and impulse noise—the amount of information available is considerable. Several extensive test programs have been undertaken, the most notable being those of the Bell Telephone Laboratories,²⁰ the International Telephone and Telegraph Corporation²¹ and those undertaken by various administrations as contributions to the International Telegraph and Telephone Consultative Committee (CCITT) Study Group Special A on Data Transmission Systems.²² Only some results of the work of Alexander, Gryb and Nast will be given here as these are considered representative.

The frequency distribution of noise pulses on telephone connections through the message network is shown in Fig. 6. Alexander, Gryb and Nast state that the correlation of impulse noise and error generation in their tests was poor, and advanced the theory that the unaccounted for factors are drop-outs and short period interruptions. In fact many investigators have voiced the suspicion that drop-outs in the communication channels may be a predominant source of errors.



Level Distribution of Impulses

Fig. 6

Information on both impulse noise and drop-outs on a representative leased telephone channel of 2000 miles in length have been presented by Kelly, Mercurio and Willard. Figures 7 and 8 show impulse noise duration distribution, and time intervals between errors respectively found by them on a Bedford, Mass.—Chicago—Bedford, Mass. channel.

More general results from the work of Alexander, Gryb and Nast relating error rates, and indirectly impulse noise, to transmission speed, received level, error correction system effectiveness and their probability of occurrence. It should be recognized that the results were obtained in a specific series of tests, using a particular type of apparatus over the American switched telephone network.

From Fig. 9 it can be seen that the error rate goes up with speed, partly due to increased distortion of the pulses and partly because the pulses are shorter in relation to noise pulses at the higher speeds. The effect of received level being dropped closer to impulse noise level on the error rate is shown in Fig. 10, and as may be expected, the error rate goes up. The probable interval between errors is given in Fig. 11 from which it can be seen that the probability of errors being closely grouped is quite high, which is a tendency that must be recognized in developing effective error correction systems. Then finally, the degree of improvement in transmission that may be expected at 600 bits per second and 1200 bits per second with representative error correcting codes is shown in Figs. 12 and 13, respectively.

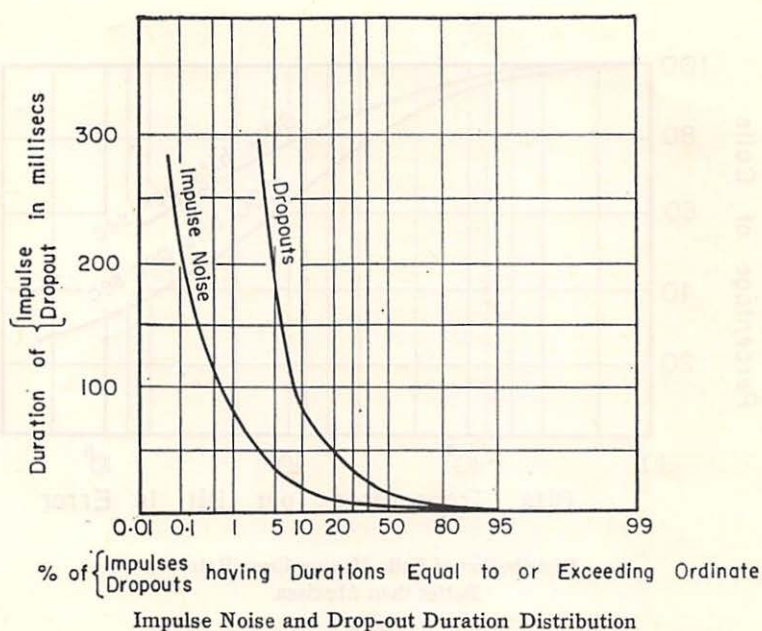


Fig. 7

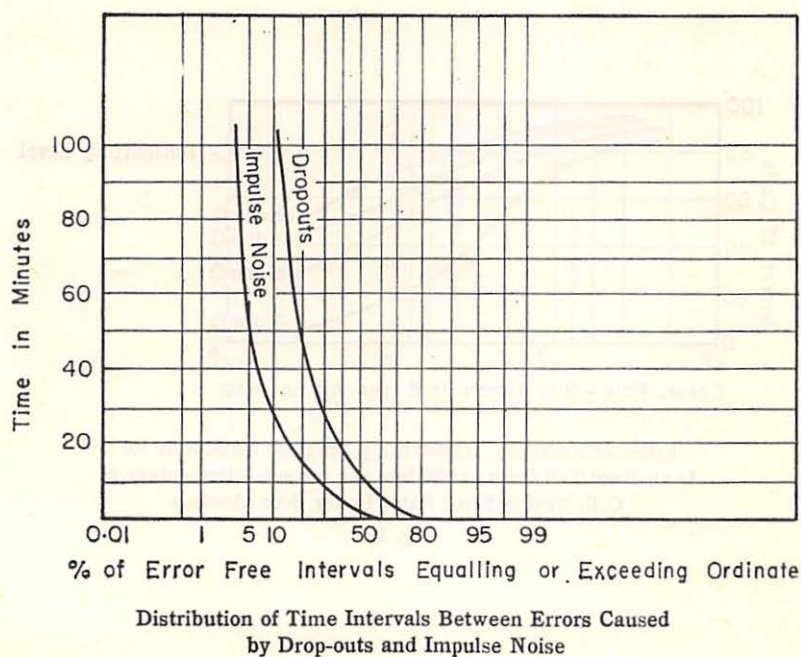
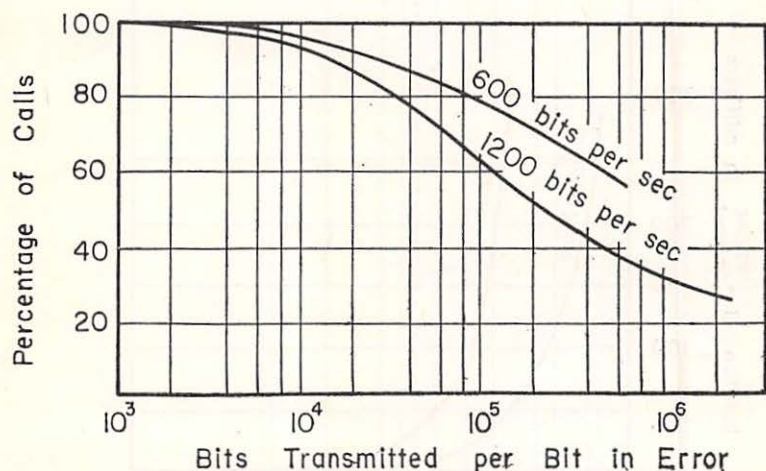
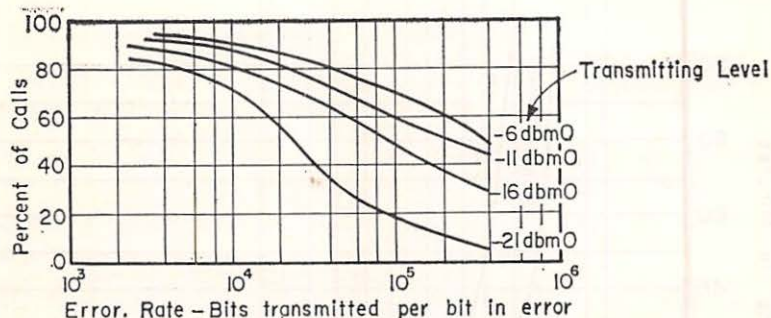


Fig. 8



Distribution of Calls Having Error Rates
Better than Abscissa

Fig. 9

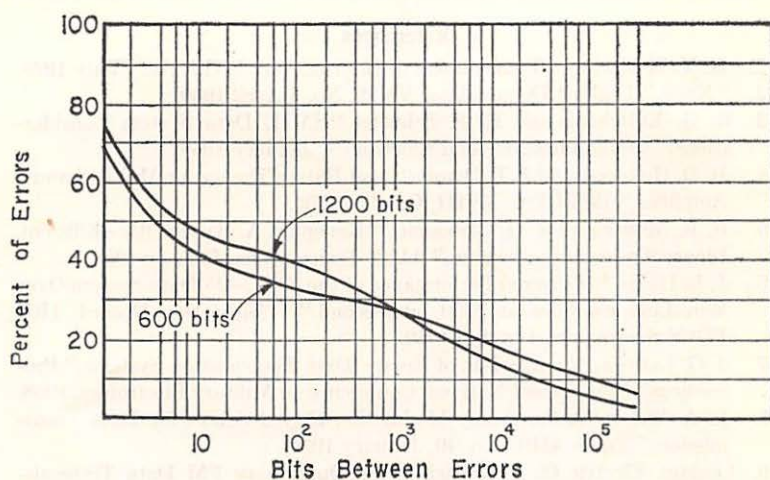


Effect of Reducing Transmitting Level on Error Rate for
Long-Haul Toll Calls at 600 bits per second— Percentage of
Calls having Error Rates better than Abscissa

Fig. 10

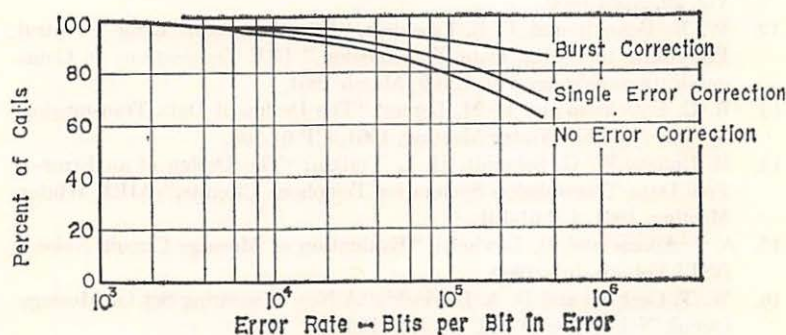
Oct. 1962]

9—Transmission



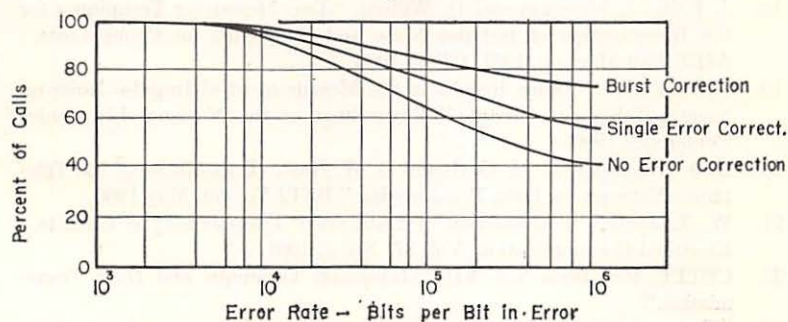
Distribution of Intervals Between Errors—Percentage of Errors having more error-free bits between them than as shown on Abscissa

Fig. 11



600 Bits per Second

Fig. 12



Distribution of Errors for Different Degrees of Error Correction—Percentage of Calls having Error Rates better than Abscissa
1200 Bits per Second

Fig. 13

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Exhibit 9-E

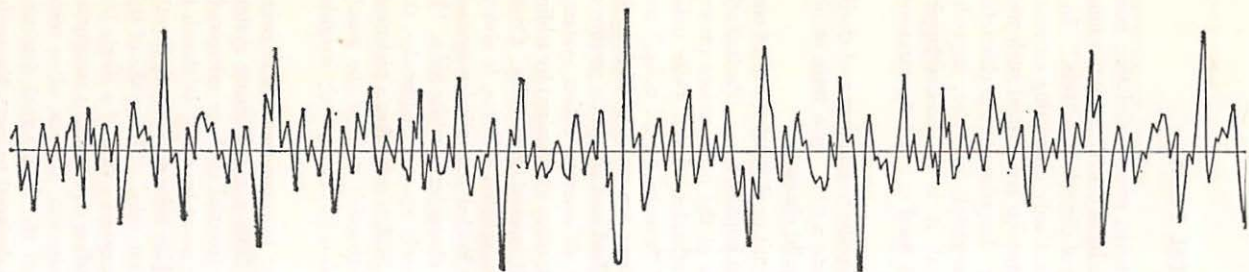
IMPULSE NOISE VS. DIGITAL DATA

Impulse noise, like white noise, interchannel noise, cross-modulation noise and all the rest is not noise at all until some transducer converts it into sound. The expression seems a bit inept when thinking of digital data "bits." In a communication transmission system, all noises are only interfering currents, unwanted currents—disturbance. Still, the expression has gained such wide usage that there should be no misunderstanding. Impulse noise is characterized by its fortuitous nature—"entirely and completely irregular, unpredictable." Electronics dictionaries point out that it is a non-overlapping transient. It could quite accurately have been defined as isolated, extraneous disturbance peaks of abnormally high magnitude.

The following discussion will attempt to explain the mechanism and clarify the thinking on how and why noise does mutilate a "bit" or a train of bits which would otherwise represent and convey a valid character.

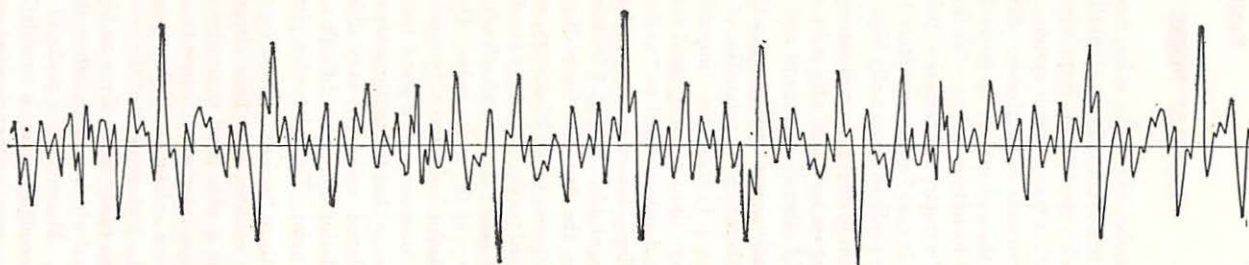
Because all "noises" ride along on the same circuit or channel one must consider all of them in any explanation of the effect of impulse noise. Particularly one must keep in mind the "impulsive" nature of the other noises present which always form a background for the real offender. Even white noise, which is variously defined as "uniform noise," "evenly spread noise," and other seemingly innocuous names, has peaks about ten times as high as its average magnitude. In Fig. 1 is shown an excellent and authentic picture of white noise, the first and basic disturbance of all communication systems. For test purposes, in the laboratory, white noise is often synthesized by adding together equal portions of a large number of equally spaced frequencies. Cross-modulation noise, the second offender in all transmission systems, is always added on top of the white noise. On a heavily loaded transmission system, cross-modulation noise has very much the same character as white noise. It, too, is the summation of a great number of closely spaced frequencies, the difference being that the portions are not equal. Still, if one takes a picture of cross-modulation noise, it's very difficult to distinguish it from the purely cross-modulation noise, it is difficult to distinguish it from the purely irregular fluctuation noise. Fig. 2 is such a picture.

Both of these "noises," added together appear in some measure in every voice width channel (telephone circuit) derived from a multiplexing system operating on a wide band transmission medium (coaxial cable or microwave radio). These interference currents are additive point by point as shown in Fig. 3. Sooner or later the highest peak of the white noise gets added directly on top of the highest peak of the cross-modulation noise. The peaks of this net noise can easily be 20 times as high as the greatest swing of a single frequency signal which would produce the same reading on a current measuring instrument. Moreover, the peaks of this net noise can, and do, often recur frequently enough to have a cumulative effect on the data signal detecting device. Conservatively engineered equipment is designed to carry the useful signal, be it speech or data, at a level many times higher than the peaks of this net, loaded system noise.



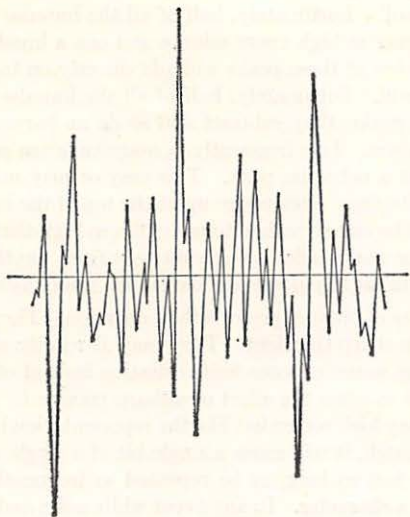
There is Nothing More "Random" Than "White Noise"

Fig. 1



Cross Modulation Noise is Almost Equally
Random but not Identical

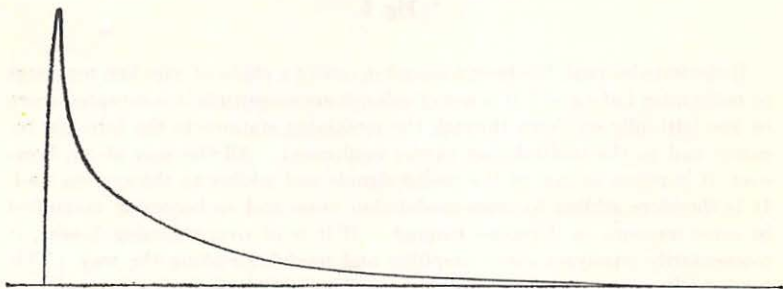
Fig. 2



Summation of Noises in Fig. 1 and Fig. 2,
Center Portion, Showing a "Master" Peak

Fig. 3

Now, from man-made and from natural sources comes the "impulse" interfering current. See Fig. 4. On the "man-made" side it comes from power line transients, elevator starters, ignition systems, even from the simple omission of a spark suppressor across a telephone ringing relay contact—from many sources. In the "natural" sources category are lightning strokes, static discharges from dust storms, and others less numerous perhaps but much more potent. In the aggregate, both the distribution and the height of all peaks in the impulse classification are completely random. In other language, there

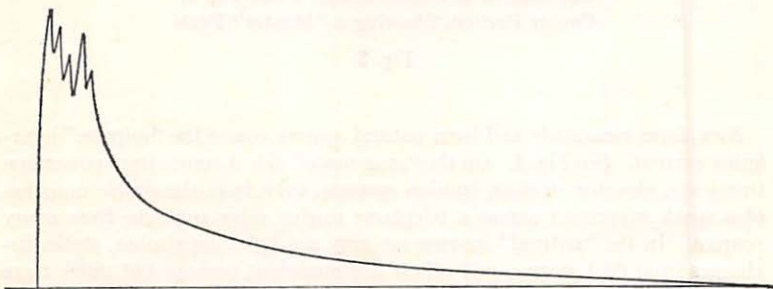


A Single Sharp Impulse

Fig. 4

may well be an impulse peak of minor size, just as often as there is a maximum peaks—but some will. Fortunately, half of all the impulse peaks do not add may be one ten times as high every minute and one a hundred times as high every hour. Very few of these peaks will add directly on top of the net noise peaks—but some will. Fortunately, half of all the impulse peaks do not add to the other noise peaks; they subtract and so do no harm at all unless they are of much larger size. Less frequently, a magnitude ten peak will sooner or later ride on top of a net noise peak. This may or may not mutilate a data bit, depending on its size. Somewhere up at the top of the impulse peak range is one which might be called "calamitous." It is so high that there need be no concern whether or not it adds to or subtracts from anything else. It will overwhelm any data bit signal without assistance from any other noise peaks.

A third parameter of impulse peaks is their duration. They are by no means confined to a single sharp transient. They may as readily appear to the telephone as a scraping sound of some finite duration instead of the sharp pistol-shot crack which is so often the effect of a sharp transient. If the duration is substantial they may look somewhat like the representation in Fig. 5. If either of these is high enough, it will cause a single bit of a single character to be in error. They may last so long, or be repeated so frequently, as to mutilate many or all bits in a character. In any event white noise and cross-modulation noise only provide a higher starting place for the impulse peak.



The Jagged Impulse, Perhaps From an
Arcing Elevator Starter Contact

Fig. 5

If the impulse peak has been induced in one of a chain of wire line repeaters or radio relay links and if it is not of calamitous magnitude it is repeated more or less faithfully on down through the remaining stations to the terminal receiver and to the multiplexing carrier equipment. All the way along, however, it is riding on top of the useful signals and adding to the system load. It is therefore adding to cross-modulation noise and so becoming magnified in some measure as it passes through. If it is of overwhelming height, it momentarily paralyzes every amplifier and modulator along the way. This tends to drag it out, prolong its duration. Some of its energy is converted into that frequency which goes most readily through every resonant circuit or filter in its path. Unfortunately, that frequency is the signal or intelligence frequency which the system was designed to transport. No transmission system

will handle an infinite amplitude. Modern systems contain feedback amplifiers, many of which are more linear, more stable, handle more load, and resist the effect of supply voltage fluctuation. But when they do finally overload, they emit the most raucous scraping sound conceivable until the overloading transient peak recedes to the non-overload value. The repeating amplifiers then, as well as the filters, help to convert disturbance peaks to signal frequency so that they may do the most possible damage.

In the multiplexing equipment, that part of the transient which is of appropriate frequency to pass through each succeeding high frequency, middle frequency, and low frequency stage shock excites each filter along the way and leaves it "ringing." Here too the noise peak is converted to signal frequency to some degree. It is fundamental that a filter will not respond to the start of a signal instantaneously, neither will it cease to deliver a frequency immediately when the stimulus is terminated. It is also fundamental that the envelope of a filter's response to a transient stimulus is about the same as the envelope of the highest rate signal being transmitted.

Assume a certain limited band has been allotted to a data channel. In general, and in round numbers, if the desired data rate is 2000 bits per second, 2000 cycles per second of spectrum width is little enough. Since binary information is to be transmitted a "yes" bit is one condition of modulation—amplitude, frequency or phase and a "no" bit is another condition. When, because of the particular character code, a "yes" is followed by a "no" in succession a few times, the "cycle" rate of the modulation is at a maximum. At 2000 bits per second the "cycle" rate is 1000 cycles per second. The principal side bands created by the modulation are 1000 cycles either side of a center frequency.

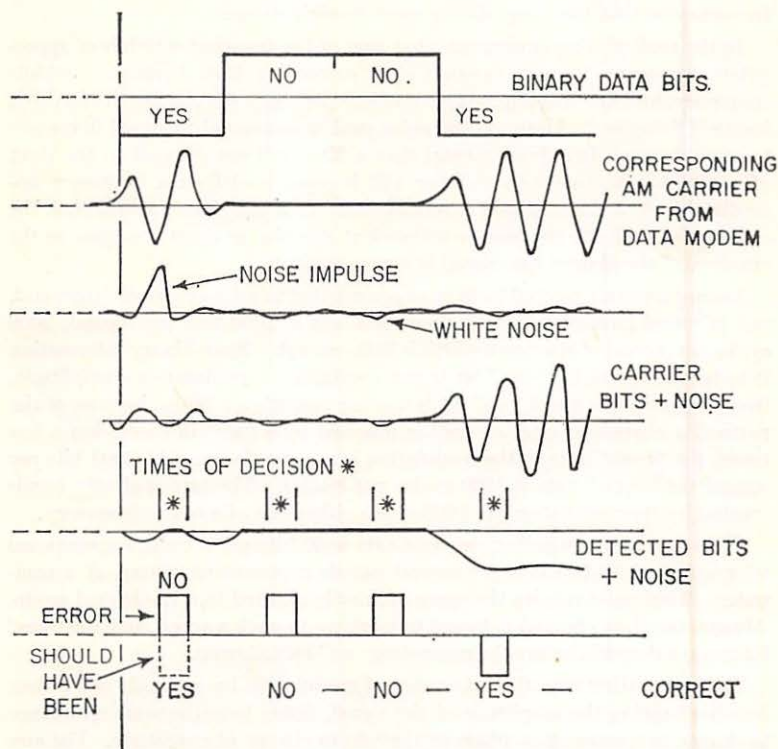
The same is true whether the data rate is 50 bits per second, conventional telegraphy, or 24,000 bits per second signals representing output of a computer. This could require the space ordinarily allotted to a 12-channel group. Always, the data channel is forced to work up to such a speed that the "yes" bit can get through, before the succeeding "no" bit follows it.

Without getting into the intricacies of modulation by methods other than simply changing the amplitude of the signal, filters have the same reluctance to change of frequency or phase as they do to change of amplitude. For any filter, wide or narrow, there is one characteristic response shape. So it follows, that if the stimulus to the filter is the sudden jolt of a peak of impulse noise, the rise and decay of the filter output is about the same shape as if the stimulus were a legitimate wanted signal. If the rise and decay consume about the same time as did the rise and decay of a bit, the disturbance is always trying to augment or cancel the bit, depending upon the timing of the two.

Consider, now, what happens when the data rate is such that this data channel is confined to a telephone channel. If a burst of noise is mixed with the desired signal, probably some of all frequencies, the components of which may or may not be evenly spaced, are present. The super group filter, channel group filters, and channel filters will each, in turn, reject most of the higher frequency components. However, within the channel some components of all frequencies between 300 and 3000 cycles are still present, i.e., there is still a noise component present in addition to the desired signal, both of which must be passed to the detector.

The detector, whether it be a simple rectifier, a frequency sensitive dis-

criminator, or a phase sensitive network, is incapable of completely discriminating between noise and signal. Figure 6 illustrates the manner in which a bit may be received in error because of the presence of a burst of impulse noise in an AM system. A similar situation can exist for any other type of modulation scheme.



How the Summation of White Noise Peak,
Cross-Modulation Noise Peak, and Minor
Impulse, all Inoffensive taken Separately,
when Combined, Mutilate a Data Bit

Fig. 6

Exhibit 9-F**REPORT ON THE EFFECT TO BOTH SIGNAL CONTROLS AND COMMUNICATIONS WHEN SIGNAL CIRCUITS AND COMMUNICATION CIRCUITS ARE OPERATED ON THE SAME WIRES OR OTHER MEDIA**

In AAR Signal Section 1951 Proceedings, Vol. XLIX, p. 304, will be found a comprehensive report entitled, "Mutual Effects that May Be Encountered in Combining Circuits on a Single Pair of Wires." The basic engineering approach outlined in this report remains unchanged, and all of the information in that report applies to present day practices. The following information should be considered as supplemental and illustrative as to the degree of such joint operations that are operating successfully.

Transmission voltages and currents for short signal control sections are substantially different from communication practices and will not be considered here. Signal transmission voltages, currents and frequencies for longer distances, such as over a centralized traffic control installation, are of the same order as those used for communications and it is this application that will be examined in this report.

Some of the reasons that favor joint operation over the same media, and some of the solutions to problems encountered are:

Reliability

Insurance against failure of open line wires has resulted in the use, in signal service for many years, of insulated high-tensile strength line wire.

Recent demands on communication services for increased reliability for data processing, etc., have made their needs similar to those for signals.

Recently constructed open wire lines of heavy conductors, insulated with either neoprene, polyethylene, or polyvinyl chloride compounds, have demonstrated that they have the reliability and transmission characteristics for joint operation if desired.

Economy

Most signal CTC code circuits use only the low frequencies and in some cases a few narrow band carrier channels for extension of the CTC control sections. This same CTC code pair if engineered, constructed, and transposed properly will handle additional communication carrier channels in that portion of the frequency spectrum not needed for signal control.

Frequency Range

The frequency ranges that both services use can be roughly grouped into these categories:

1. Direct current and low frequency pulsing—to 300 cycles per second.
2. Voice frequency—300 cycles per second to 3000 cycles per second.
3. Low frequency carrier—3 kilocycles to 30 kilocycles.
4. High frequency carrier—30 kilocycles to 150 kilocycles.

Some overlapping of these ranges may be encountered and some higher frequencies may be used. Amplitudes of the transmitted signals for both services can be designed to be compatible and stay within accepted practices.

Line Transmission Characteristics

1. **Open wire**—CTC code wires must meet the dual requirement of low direct current resistance over any one control section, and satisfactory high frequency transmission to allow additional sections to be controlled by carrier. Experience has shown that standard 30 kilocycle transposition patterns give smooth impedance and attenuation characteristics in some cases up to 150 kilocycles. High frequency attenuation, from perhaps 10 kilocycles up, will be slightly increased due to the slower velocity of propagation of the insulated wire. This increase may be of the order of 10 to 15 percent at the higher frequencies. Circuit layout and repeater spacing should be made accordingly.

2. **Cable**—Communication cables, used at either terminals or intermediate locations, have satisfactory transmission characteristics for voice and carrier frequencies. In some applications, separation filters, cable loading coils, or impedance matching transformers are used to reduce the attenuation at voice or carrier frequencies. At direct current and lower CTC code pulse rates the loop resistance of the small gage communication cable may be too high. On the other hand, most heavy gage signal cables do not have paired conductors with satisfactory balance to earth and the other conductors to permit satisfactory voice and carrier transmission without undue noise being introduced. In the case of a new installation these faults could be corrected by either incorporating heavy gage conductors in the communication cable or by including balanced pairs in a signal cable. In installations using existing paralleling signal and communication cables it is possible to use a specially designed low pass filter to transfer the direct current and CTC code pulses from open wire into signal cables, by-passing the voice and carrier frequencies through communication cables. This will be treated in greater detail below.

Example:—To illustrate the extent to which joint operations can be extended and also point out special design features that may be necessary, a recently completed system will be described.

This is a 60-mile CTC installation with 12 signal locations operating over No. 8 copperweld, 40 percent conductivity open line wire insulated with $\frac{3}{4}$ inch neoprene covering. Transpositions are a standard 30 kilocycle pattern. Operating over this pair are:

- (a) Traffic control d-c line circuit.
- (b) 300-3000 cycle dispatchers voice telephone.
- (c) 5-30 kc three channel carrier telephone.
- (d) 40-150 kc twelve channel carrier telephone.

The dispatcher does not use $3\frac{1}{2}$ cycle code ringing over the voice channel as it would interfere with the CTC code signals. Open stations are equipped with a way station amplifier bridged onto the dispatcher's circuit.

Note should be made that the frequencies between three and five kilocycles are reserved for future use of narrow band carrier channels to extend the CTC to another section.

Special Design Features

40 CPS low pass filter—As mentioned above, neither signal nor communication cables used at terminal or intermediate points on this installation had both the transmission characteristics and/or direct current resistance to handle both the direct current and higher frequency signals. To bypass direct current and CTC code pulses around communication cables and equipment, the signal company has designed a special low pass filter. This is a full section, constant K, iron core design. Cut-off frequency is approximately 40 CPS, and the direct current resistance is quite low. The requirement for 40 cycle cut-off and low d-c resistance resulted in quite a large structure measuring approximately 6 by 8 by 10 inches and weighing 25 pounds. Typical application of this filter is shown on Figs. 1 and 2.

Figure 1 shows a typical entrance cable installation. Choice of impedance matching techniques and carrier line filters should be made on the basis of the type and frequency range of the carrier involved. When 150 kc carrier is used it may be desirable to locate the carrier filters at the junction of open wire and cable, and use separate pairs in the communication cable for 0-30 kc and 40 to 150 kc for ease of impedance matching. This same approach can be taken to transfer CTC code signals around a small gage communication cable at an intermediate point or at a voice or carrier location.

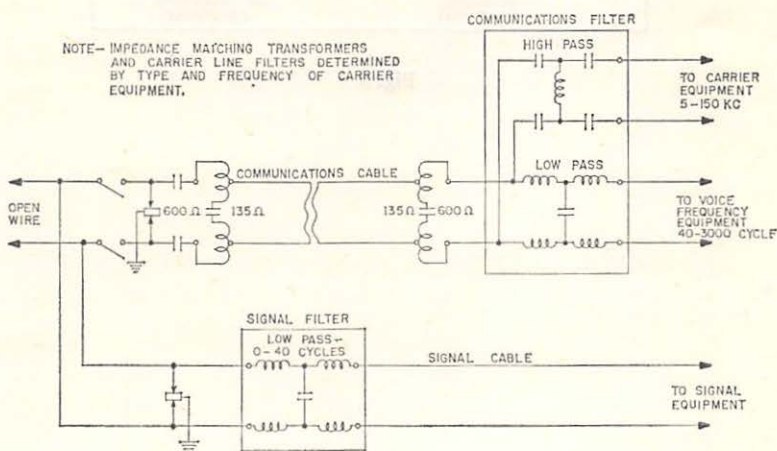


Fig. 1

Note should be taken on Fig. 2 that the drop wire, into a signal bungalow or other intermediate location, is shown with 6-inch spacing between the wires. This is done to eliminate the use of a "pole top" filter to block carrier frequencies from the drop wire. Also the wide spacing on the drop wire presents a minimum impedance irregularity to the open wire line. This technique is satisfactory if the bridged drop is very short. If the bridged drop exceeds 25 to 30 feet it may be necessary to install a pole mounted low pass filter with suitable

electrical protective devices to minimize the bridging loss of the drop to the carrier frequencies.

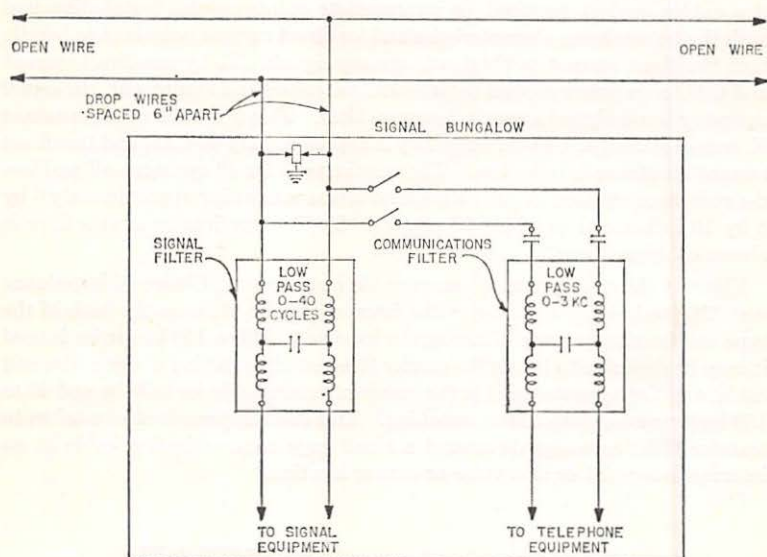


Fig. 2

Exhibit 9-G

REPORT ON NEW TRANSMISSION MEASURING TECHNIQUES

The Level Tracer, an Instrument for Time Saving and Better Measurement in the Speech Band

The development and construction of a visual voice frequency transmission measuring set is described and a short summary of its applications is included. The instrument provides for the display of measurements of level, impedance, return loss, impedance comparison on the face of a CRT as a function of frequency. The values in db or ohms are read directly from a calibrated graticule. The instrument described is the latest of a series whose initial development was begun in 1941.

The growing number of telephone connections, the increased demands on transmission performance, and the ever more serious shortage of skilled personnel have strongly emphasized the need for communications measuring instruments, which provide for better measurement together with a reduction in the time required. Better measurement means more extensive and accurate measurements than those normally performed during the installation and maintenance of transmission facilities. Unfortunately, with conventional measuring instruments, this requirement can only be met with great expenditure of time and labor. To reconcile these opposing demands, a novel instrument, providing swept measurement of the entire voice band with cathode-ray tube readout, was developed in Germany and marketed under the name Level Tracer. The development of the technique of measurement exemplified by this instrument dates from World War II and an earlier version is described in a previously published paper.

Spectrum Generator for Transmission Testing of Wire Facilities

Normally, transmission measurements are made by the relatively slow point-by-point method. Swept frequency techniques are quicker, but may interfere with the transmission system's normal operation. A spectrum generator is described which simultaneously supplies a number of uniformly spaced test tones within the carrier facilities frequency range. A manually tuned, or sweeping selective detector, used as a receiver, will yield the system's transmission characteristic. By this method the speed of the swept frequency method is attained without its disadvantages.

A Spectrum Generator has been designed to help in equalizing and maintaining carrier frequency facilities such as the K, N, ON and ON/K systems. The generator simultaneously supplies a number of uniformly spaced test tones within the frequency range of the carrier frequency facility being tested. With such a generator at the sending end, the attenuation frequency characteristic at the receiving end may be observed by means of a manually tuned or swept spectrum analyzer. The advantage of such a device is that regardless of which type of analyzer is used, it is only necessary to man the receiving end of the circuit being measured.

Swept-Band Transmission Measuring Set

Many recent innovations in the field of communications have caused an increasing awareness of the need for stricter quality control. The increase in the use of Direct Distance Dialing, special leased wires, extended calling areas,

and data transmission have all caused the industry to become more quality conscious than ever before. Accurate information of the transmission characteristics must be obtained for many circuits in order that both proper initial installation as well as strict maintenance control may be observed. With conventional test equipment, the determination of circuit information over the entire voice-band is very time-consuming and ties up valuable personnel at multiple locations.

The ultimate solution undoubtedly lies in the development of an automatic device which will continually probe every trunk on a whole-band basis for flatness and net loss and pass it for service or reject it for maintenance with a fault record. Some progress has already been made in this direction on a single-frequency basis. Such a device is certain to be expensive and some years away.

In order to fill the immediate requirement for an instrument capable of rapid examination of transmission characteristics, a new type instrument known as the Swept-Band Transmission Measuring Set has been designed.

Essentially, the Swept-Band Transmission Measuring Set consists of a sweep-frequency generator, detector, measuring system and visual display on the face of a long persistence cathode ray tube. By means of a contact modulator or "electronic-chopper" located at the input to the vertical deflection plates, first the oscillator output and then the detector input are sampled at a very rapid rate during the excursion across the horizontal axis. This excursion takes approximately one second, and at every 1000 cycles, there are marker pulses superimposed. The sweep-frequency generator varies the frequency from 200 cycles to 4000 cycles. The output level is adjustable from -20 dbm to +10 dbm and may be verified by means of a meter incorporated on the instrument panel.

A built-out circuit permits adjustment of the sweep-frequency generator for 600 ohms, 900 ohms or high impedance circuit matching. A means of initial calibration is also included within the instrument.

Loss or gain in the range of -55 dbm to +35 dbm may be read directly from an attenuator setting.

In many applications, the ends of a facility are not always available at the same test point. In such cases either of the two following procedures may be used:

(a) A "loop around" method in which a known return path is used to bring back the farther end of the circuit to the test point.

(b) Two swept-band instruments are used, and by means of internal circuitry, synchronization may be accomplished via the same pair being tested through operation of a push button located on the face of the instrument.

The instrument weighs 56 pounds and is designed for standard 19-inch relay rack mounting. When used as a portable instrument, it may be enclosed in a carrying case or specially designed dolly.

References:

A Voice-Band Transmission Measuring Set Using Swept-Band Techniques (59-1254) by Worthington C. Lent—Presented at the Fall General Meeting AIEE, October 15, 1959.

The Interpretation of Results Obtained with a Swept-Band Transmission Measuring Set (PC 60-823)—By S. L. Wilson, Jr.

Presented at the Summer General Meeting AIEE, June 23, 1960.

REPORT OF
COMMITTEE 10—INTERLOCKING, TRAFFIC CONTROL AND
BLOCK SIGNALING

- H. A. Maynard (Chairman), Assistant Engineer Signals, Baltimore and Ohio Railroad.
V. S. Mitchell (Vice-Chairman), Signal Engineer, Chicago and North Western Railway.
J. A. Balla, Engineer Communications and Signals, Pennsylvania Railroad.
H. R. Beck, Engineer of Signals, Canadian National Railways.
T. L. Carlson, General Superintendent Signals and Communications, Chesapeake and Ohio Railway System.
W. E. Fuhr, Assistant Chief Engineer Signals and Communications, Chicago, Milwaukee, St. Paul and Pacific Railroad.
W. W. Hartzell, Engineer Signals and Communications, Boston and Maine Railroad.
H. A. Hudson, Assistant to Vice President, Signal and Electrical, Southern Railway System.
H. Jensen, Signal Engineer, Chicago, Rock Island and Pacific Railroad.
C. T. Marak, Signal Engineer, Missouri Pacific Railroad.
G. Pipas, Signal Engineer, Illinois Central Railroad.
W. S. Pipas, Superintendent Signals, Gulf, Mobile and Ohio Railroad.
M. R. Roberts, Principal Assistant Signal Engineer, Burlington Lines.
V. P. Shepardson, Assistant Chief Engineer-Signals and Communications, Richmond, Fredericksburg and Potomac Railroad.
H. G. Stiebeling, Signal Engineer, New York, Chicago and St. Louis Railroad.
H. C. Stratton, General Signal Engineer, Union Pacific Railroad.
W. K. Waltz, Signal Engineer, Elgin, Joliet and Eastern Railway.

Railroad Consulting Member

- K. O. McClure, Signal Engineer, Kansas City Terminal Railway.

Consulting Members

- A. T. Johnston, Consulting Engineer, Union Switch and Signal Division of Westinghouse Air Brake Company.
R. J. Little, Standards Engineer, General Railway Signal Company.

June 1, 1962

TO THE COMMUNICATION AND SIGNAL SECTION:

The following subjects have been assigned to this committee:

1. General review of Manual.
2. Report to the Special Committee on Research Assignments any projects considered proper for submission to AAR Research Center.
3. Specification for yard switching system.

4. Investigate and report on methods of improving shunting of track circuits.
6. Collaborate with AAR Joint Committee on Relation Between Track and Equipment in the study respecting the rollability of cars.
7. Collaborate with AREA Committee 28—Clearances.
8. Collaborate with Joint Committee of Mechanical and Engineering Offices, AAR, to Study Clearances above Top of Rail, Vertical Curvature on Humps, etc.
9. Collaborate with Mechanical Division Committee on Car Construction on the subject of Car Designs—Dimensions and Clearances.
10. Collaborate with Joint Subcommittee of the AAR Mechanical Division regarding the ability of off-tread brakes on freight cars to adequately shunt track circuits.
11. Investigate and report on the effects of continuous rail on insulated joints.
12. Investigate and if found desirable prepare specifications for automatic type rectifiers.
13. Investigate and report on various types of detectors used in connection with signal systems for protection of trains and equipment.
14. Investigate and report on methods of installation of track circuit connections to facilitate the use of mechanized track maintenance equipment.
15. Investigate and report on all phases of retardation and automatic route selection in classification yards equipped with car retarder systems.
16. Investigate and report on the use of devices to detect defective wheels.
18. Investigate and report on the location and mounting of devices used to determine the presence of heat in journals or car wheels.
19. Investigate and report on procedure for operating in traffic control territories when control features become inoperative.
20. Investigate and report with respect to proper location of communication equipment in signal consoles.

The committee submits for consideration, reports on the following subjects:

1. **Revision of Signal Specification 179-48—Mechanically Applied Rail Head Type Bonds and Track Circuit Connectors**, as Exhibit 10-A, page 200, to supersede Signal Manual Part 142.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

1. **Revision of Signal Drawing 1048C—Mechanically Applied Rail Head Type Bonds and Track Circuit Connectors**, as Exhibit 10-B, page 203, to supersede drawing in the Signal Manual. Drawing revised in line with revision of Manual Part 142.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

1. **Revision of Signal Instructions for Mechanically Applied Rail Head Type Bonds and Track Circuit Connectors**, as Exhibit 10-C, page 204, to super-

sede Signal Manual Part 219. These instructions revised to conform with revised Manual Part 142.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

1. **Revision of Signal Specification 258-60-Interlockings**, as Exhibit 10-D, page 206, to supersede Signal Manual Part 83.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

1. **Switch Operating Mechanism for Yards, Specification 274-62**, as Exhibit 10-E, page 231. This is a revision and consolidation of Signal Manual Parts 182, 255 and 256; namely, Signal Requisites for Switch Operating Mechanism for Slow Speed Train Movements, Signal Specification 247-49 Electric Switch Operating Mechanism for Yards and Signal Specification 243-49 Electro-Pneumatic Switch Operating Mechanism for Yards and if approved will supersede these Signal Manual Parts.

Action Recommended

Acceptance for submission to letter ballot superseding subject matter in the Signal Manual.

4. **Report on Methods of Improving Shunting of Track Circuits**, as Exhibit 10-F, page 237.

Action Recommended

Acceptance as information.

Respectfully submitted,

COMMITTEE 10—INTERLOCKING, TRAFFIC CONTROL
AND BLOCK SIGNALING

Exhibit 10-A(Revision of AAR Signal Section Specification 179-48)
AAR SIGNAL SPECIFICATION 179-62**MECHANICALLY APPLIED RAIL HEAD TYPE BONDS****1. Purpose**

(a) This specification is for the purpose of providing for mechanically applied rail head type bonds for track circuits. It sets forth specific detail requirements representing modern signal practice recommended for new installations and for replacement of existing material when general renewal or replacement becomes desirable.

2. Drawings

(a) Drawing 1048 forms an essential part hereof.

3. Tender

(a) The tender shall be for a product meeting the requirements of this specification in its entirety.

4. Purchaser's Order Requirements

(a) The following additional requirements will be shown on purchaser's order:

1. Type of bond.
2. Formed length of bond when other than standard length is desired.
3. Inspection and tests as required.

5. Material and Workmanship

(a) Material and workmanship shall be first-class in every respect.

6. Design

(a) General construction and dimensions of bonds and punch shall conform to Drawing 1048.

7. Conductors

(a) The flexible stranded conductor, composed of hard-drawn cadmium bronze wire, shall be made in rope lay construction, 7 strands of 19 wires in each strand, having a nominal diameter of $\frac{3}{16}$ in. and meeting the following mechanical and electrical properties:

Minimum breaking strength, lbs.....	1200
Nominal weight, lbs. per 1000 ft.....	65
Nominal resistance, ohms at 68 F. per 1000 ft.....	0.670

(b) Bronze wire shall meet the requirements of ASTM current Specification B105, alloy 80.

8. Terminals

(a) Terminals shall be made in accordance with manufacturer's designs, approved by purchaser, and suitable to be installed in drilled hole as shown on Drawing 1048.

1. Type H terminals shall be so designed that when installed the shoulder shall clear the ball of rail not less than $\frac{1}{32}$ in. and so that the

8. *Terminals—Continued*

terminals may be extracted without damage to the hole or to the bond for reuse if otherwise in good condition.

2. Type P terminals shall be so designed that when installed, the terminals shall completely fill the hole with little, if any, of the terminal extending therefrom.

(b) Assembly of terminals to conductors shall be in accordance with manufacturer's designs and approved by purchaser.

9. *Plating and Tinning*

(a) Terminals when made of steel shall be plated with zinc or cadmium.

(b) Plating material shall be commercially pure metal.

(c) Terminals when made of copper shall be plated with zinc, cadmium, or tin.

(d) Tinning material shall be commercially pure tin or lead tin alloy, not less than 65 percent tin.

10. *Identification*

(a) Each terminal shall be so marked or of such individual design that manufacturer of the bond can be readily identified prior to installation.

11. *Resistance of Installed Bonds*

(a) When installed in 0.385 in. diameter by 0.250 in. depth drilled holes in steel plates 2 in. wide and $\frac{3}{16}$ in. thick, the electrical resistance shall not be in excess of 500 microhms. Contact points for resistance test shall be made on the outer ends of steel plate within one inch of terminals.

(b) Tests shall be made by the ammeter—milli-voltmeter or Kelvin bridge method with current taps at edge of plates outside of span of bond, on line through terminal centers. Potential contacts shall be made on clean steel at points exactly one inch from axial center of drilled holes and exactly on line passing through centers of drilled holes. Plates shall be effectively insulated. Tests shall be made at room temperature. Direct current shall be used at a value not in excess of 10 amperes.

12. *Inspection*

(a) Purchaser may inspect the material or product at all stages of manufacture.

(b) Purchaser may inspect the completed product to determine that the requirements of this specification have been met.

(c) If product has not been accepted at point of production and if, upon arrival at destination, it does not meet the requirements of this specification, it may be rejected, and manufacturer, upon request, shall advise purchaser what disposition is to be made of the rejected product. Manufacturer shall pay all freight charges.

(d) If purchaser is to make inspection at point of production it shall be so stated on purchaser's order.

13. *Tests*

(a) Tests may be made at point of production, or on samples submitted, and may also be made at destination.

(b) Manufacturer shall give purchaser sufficient notice of time when the material or product will be ready for testing.

(c) Manufacturer shall provide, at point of production, apparatus and labor for making required tests under supervision of purchaser.

13. *Tests—Continued*

(d) If tests are to be made at point of production, it shall be so stated on purchaser's order. Purchaser shall indicate which of the tests herein specified are to be made and what portion of the material or product shall be tested.

(e) A quantity of 10 bonds taken at random from each 3000 or less may be selected by purchaser for examination as to detail finish, general quality of manufacture, conformity to dimension requirements of Drawing 1048; or purchaser may at his discretion inspect entire lot.

(f) For breaking load test of finished cable not more than two 24-in. test specimens fitted with suitable test terminals shall be furnished by manufacturer at request of purchaser. Test values must not be less than values required in section 7-a.

(g) Two samples installed in steel plates in accordance with section 11-a may be supplied by manufacturer under supervision of purchaser for electrical test. Electrical resistance must not be more than the requirements specified in section 11-a.

(h) If one or more of the tensile test samples fail to meet the requirements specified in section 7-a, the entire lot represented may be rejected.

(i) If electrical test values fail to come within the requirements specified in section 11-a, manufacturer may be permitted to prepare two additional test specimens, under supervision of purchaser. If one additional test fails to meet the values called for, the entire lot represented may be rejected.

(j) If two or more of the 10 samples selected for visual examination fail to meet the requirement of the specification as to finish or conformity to dimensions, purchaser at his discretion may call for 10 additional samples for examination. If additional samples fail to meet requirements, the entire lot may be rejected; or purchaser may examine each item, rejecting such as fail to conform.

(k) Plating shall be tested in accordance with Specifications for Metallic Coating of Metals, Manual Part 63.

14. *Packing*

(a) Bonds of standard length shall be packed in cartons of 250 bonds.

(b) Bonds of other than standard length shall be packed in suitable cartons for convenient handling. Gross weight of carton shall not exceed 50 lbs.

(c) A punch shall be included in each carton of Type P bonds.

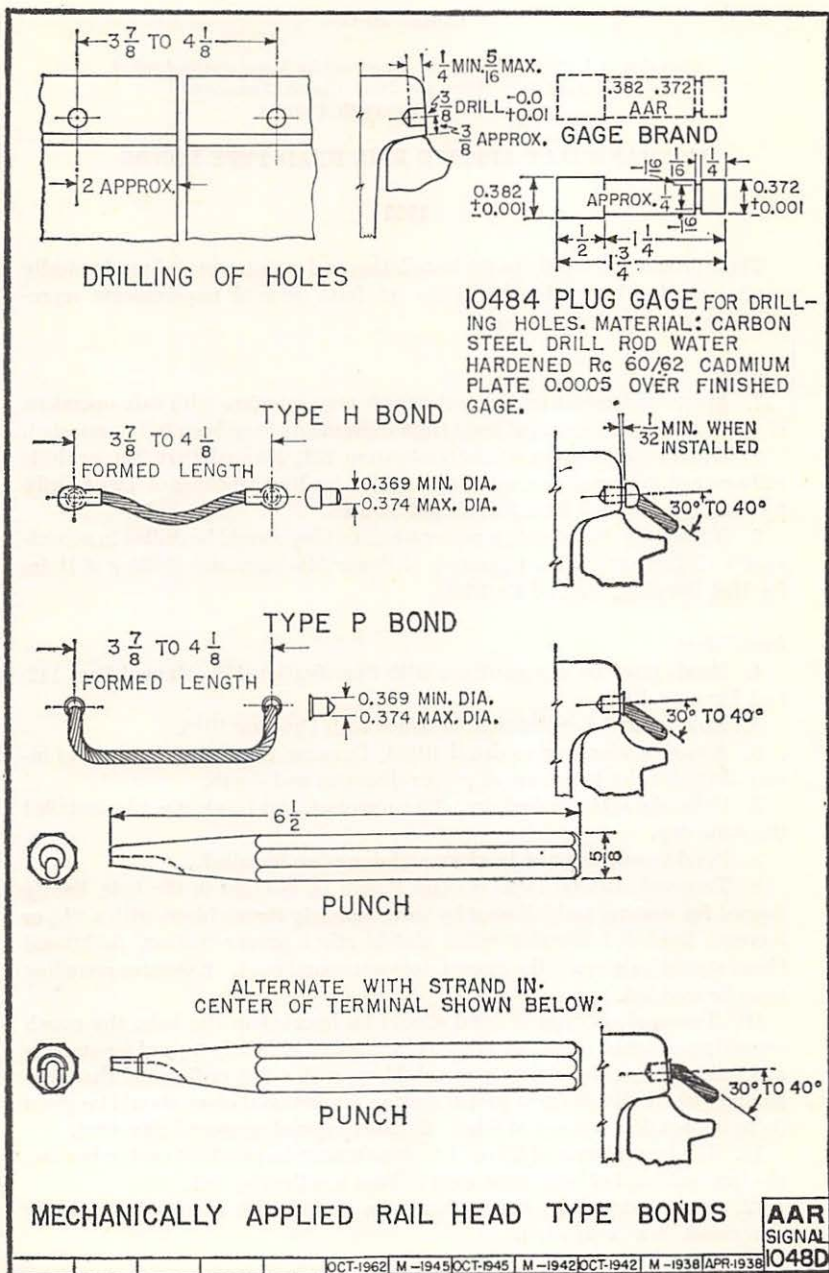
15. *Marking*

(a) Purchaser's order, requisition and package number, name of consignor, and name and address of consignee, shall be plainly marked on outside of shipping cartons.

16. *Warranty*

(a) Manufacturer shall warrant the product covered by this specification to be free from defects in material and workmanship under ordinary use and service, his obligation under this warranty being limited to manufacturing, at point of production, any part or parts to replace those which shall be found defective within one year after shipment to purchaser. This warranty shall not apply to any product which has been subjected to misuse, negligence or accident.

Exhibit 10-B



Material shall be in accordance with Specification 179, Manual Part 142.

Exhibit 10-C

(Revision of AAR Signal Section Instructions for Mechanically Applied
Rail Head Type Bonds and Track Circuit Connectors)
AAR SIGNAL INSTRUCTIONS*

MECHANICALLY APPLIED RAIL HEAD TYPE BONDS

1962

These instructions apply to the installation and maintenance of mechanically applied rail head type bonds. They set forth general requirements representing recommended practices.

General

1. Maintenance and repair work which may interfere with safe operation of trains must not be started until train movements have been fully protected.
2. Drills in accordance with Specification 254, Manual Part 259, or drills resharpened in accordance with Instructions for Resharpening of Twist Drills for Bonding, Manual Part 261, should be used.
3. If holes are drilled with a power machine they should be drilled in accordance with Instructions for Operation of Power Machines and Drilling of Holes for Rail Bonding, Manual Part 260.

Installation

4. Bonds must be in accordance with Specification 179, Manual Part 142, and Drawing 1048.
5. Holes must be drilled in accordance with Drawing 1048.
6. A gage conforming to detail 10484, Drawing 1048, must be used to insure that all holes in rail are of proper diameter and depth.
7. Holes should be drilled dry, chips removed, and bonds must be installed the same day.
8. Bond terminals must be clean and dry when installed.
9. Terminal stud of Type H bond should be inserted in the hole, lightly tapped for starting and followed by three squarely struck blows with a 2½ or 3-pound flat-faced hammer which should effect proper seating. Additional blows should be given if the impact does not sound solid. Excessive pounding must be avoided.
10. Terminal of Type P bond should be inserted in the hole, the punch properly positioned on the outer face of the terminal lightly tapped for starting and followed by three squarely struck blows with a 2½ or 3-pound flat-faced hammer which should effect proper seating. Additional blows should be given if the impact does not sound solid. Excessive pounding must be avoided.
11. The bond sleeves of Type H terminals must lie parallel to splice bar and the terminal head of bond must clear rail not less than 1/32 inch.
12. After installation, bonds should be coated with a corrosion-resisting compound, or as instructed.

* The terms "general or detailed instructions" and "as instructed" as used herein refer to individual railroad instructions.

Installation—Continued

13. Manufacturer's instructions must be followed unless they conflict with general or detailed instructions, in which case proper authority must be consulted for correct procedure.

Maintenance

14. Bonding must be inspected as instructed and replaced when necessary.

15. To remove bonds:

(a) Type H. An extracting tool as specified in manufacturer's instructions should be used, placing the forked end of the extracting tool between the terminal and the rail, if necessary, driving the extracting tool until wedged under the terminal head, being careful not to cut the terminal. Then pry out the terminal.

(b) Type P. Drill out or use extracting tool as instructed.

16. When bonds or holes are to be reused, holes should be to gage. Terminal studs and holes must be thoroughly cleaned.

Building-Up and Heat Treating of Rail Ends

17. When rail ends are heat treated, bonding must be handled in accordance with Instructions for Track Welding or Heat Treating in Track Circuit Territory, Manual Part 156.

Exhibit 10-D(Revision of AAR Signal Section Specification 258-60)
AAR SIGNAL SPECIFICATION 258-62**INTERLOCKINGS AND TRAFFIC CONTROL SYSTEMS****1. Purpose**

(a) This specification is for the purpose of providing for the installation of electric, electro-mechanical, mechanical, electro-pneumatic, automatic and relay type interlockings, and traffic control systems. It sets forth specific detail requirements representing modern signal practice recommended for new installations and for the replacement of existing installations when general renewal or replacement becomes desirable.

(b) Further specific details peculiar to electro-mechanical and mechanical interlockings are covered by Manual Part 76.

*General Provisions***2. Details of Work**

(a) Details of work include the following:

1. Buildings.
2. Power supply:
 - (a) Electric.
 - (b) Pneumatic.
3. Distributing system:
 - (a) Aerial.
 - (b) Surface.
 - (c) Underground.
 - (d) Submarine.
 - (e) Main air pipe line.
4. Control apparatus.
5. Interlocking machine.
6. Control machine.
7. Foundations.
8. Switch operating mechanism and fittings.
9. Switch-and-lock movement and fittings.
10. Electric or mechanical switch locks.
11. Signals.
12. Tracks to be signaled:
 - (a) Single track.....miles.
 - (b) Two tracks.....miles.
 - (c)tracks.....miles.
13. Communication system.
14. Wires and cables.
15. Conduit and supports.
16. Instrument and battery housings.
17. Insulation.
18. Rail bonding.
19. Painting.
20.
21.

Note.—The recommended forms of construction contracts and bond will be found in the Manual of the American Railway Engineering Assn., Chapter 20—Contract Forms, Part 1.

3. *Requisites, Specifications, Drawings, Instructions and Standards*

(a) Requisites, specifications, drawings, instructions and standards referred to in the body of this specification form an essential part hereof.

(b) Purchaser's drawings should include the following:

1. Track and signal plan or map drawn to scale with information as to grades and alignment; interlocking stations; existing and proposed signals designating type, signal numbers; location and capacity of existing junction boxes, relay and battery housings; location and size of main air line; existing and proposed switches, derails and movable point frogs, designating their normal position and whether interlocked; power stations or source; steam and electric railway and highway crossings, including undergrade and overgrade; highway crossing protection; pole line or other supports for line wires or aerial cables; number of poles per mile; average distance of pole line from track; location, number, kind or type, and size of underground cable, conduits, ducts, manholes, and junction or terminal boxes; weight and section of rail; turnout numbers; kind and condition of ballast and such other physical characteristics or information as is desirable. Drawing _____, dated _____.

2. Circuit plans for existing installations in the territory to be signaled. Drawing _____, dated _____.

3. Plans showing location and capacity of existing junction boxes, relay and battery housings. Drawing _____, dated _____.

4. Plans showing typical circuits for the control of power-operated switches and signals; switch indicators; protection for facing and trailing point switches; main line and siding crossovers; highway crossing signals; train order signals and other devices. Drawing _____, dated _____.

5. Detail drawing of interlocking station building. Drawing _____, dated _____.

6. Such standards and other drawings as purchaser desires to furnish. Drawing _____, dated _____.

(c) After contract is awarded, purchaser shall furnish contractor, as required, prints of purchaser's approved drawings that form an essential part of this specification.

(d) Framed track diagram shall be furnished in place by purchaser, in interlocking station. *R-3-d.

(e) Manipulation chart shall be furnished in place by purchaser, in interlocking station. *R-3-e.

(f) Contractor's drawings.

1. Contractor shall furnish with his proposal, drawings or references for the apparatus he proposes to furnish, which are not covered by the drawings furnished by purchaser.

2. Within _____ days after receipt of the drawings, purchaser will indicate any corrections that may be necessary, or signify his approval.

3. Contractor shall be responsible for the correctness of all drawings furnished by him, although the drawings may have been approved by purchaser.

* Alternate requisites section.

3. *Requisites, Specifications, Drawings, Instructions and Standards—Continued*

4. Any work done by contractor prior to the approval of contractor's drawings will be done at contractor's risk, unless previously authorized in writing by accredited representative of purchaser.

5. No change shall be made in any approved drawing without the written consent of purchaser.

6. After completion of contract, contractor shall designate on station map the location of underground cables, main air lines, air strainers, auxiliary reservoirs, valves, alcohol feeders, branch connections and expansion joints, and shall furnish purchaser corrected tracings of drawings furnished by him in accordance with section 3-g.

(g) After award of the contract and before work is begun, contractor shall furnish for the approval of purchaser, the following drawings as scheduled by purchaser (*R-3-g):

1. Track plan showing instrument housing, switches, signals and track circuits, within days.

2. Detail circuit plans, within days.

3. Instrument case wiring plans, within days.

4. Cable diagrams, within days.

5. Pole line diagrams, within days.

6. Contractor shall furnish purchaser, as required, prints of contractor's approved drawings that form an essential part hereof.

7.

8.

4. *Furnished by Purchaser*

(a) Purchaser will obtain necessary permits from Federal, State and Municipal authorities.

(b) Purchaser will furnish, as indicated in sections 4-c, d and e, material or labor, or both, on the following items:

1. Ties for support of apparatus.

2. Move ties as may be necessary.

3. Switches, derails and movable point frogs of the required throw.

4. Move switch and tie rods as may be necessary.

5. Track bonding.

6. Insulated rail joints.

7. Bridge insulations.

8. Switch-rod insulations.

9. Tie-rod insulations.

10. Gage-plate insulations.

11. Gage, switch and butt plates.

12. Rail braces.

13. Concrete:

(a) Transit mixed.

(b) Mixed at site.

(c) Precast.

14. Necessary grading and drainage.

* Alternate requisites section.

4. *Furnished by Purchaser—Continued*

15. Excavation of solid rock.
16. Poles, guy wires, anchors and bracing for aerial lines.
17. Crossarms, pins, insulators and fittings.
18. Line wire.
19. Battery housings.
20. Signal bridges.
21. Cables:
 - (a) Aerial.
 - (b) Submarine.
 - (c) Underground.
 - (d)
22. Conduit:
 - (a) Main.
 - (b) Branch.
 - (c)
 - (d)
23. Manholes.
24. Sand, clay or loam for cable trench, including protection plank.
25. Apply necessary attachments to signal apparatus in service.
26. Make necessary alterations of any part or existing structures or apparatus.
27. Unload and properly house material that arrives on the ground before contractor's force; this work to be done under the supervision of contractor's representative.
28. Distribute material.
29. Buildings.
30. Conduit and wire chase in buildings.
31. Power supply.
32. Tools, fixtures for building and supplies required for the maintenance of the system.
33. Automatic time recorder.
34. Submarine air pipe line.
35. Prior to installation, furnish stakes establishing grade of track at points where required.
36. Communication system.
37. Number plates.
38. Remove existing cross-bonding where necessary (electric roads).
39.
40.
- (c) Material only on items
- (d) Labor only on items
- (e) Material and labor on items
- (f) Purchaser will furnish the items as indicated in sections 4-c, d and e, subject to inspection of contractor, who shall state any objections thereto before starting his part of the work. After rectification by purchaser of any defects reported, contractor shall assume full responsibility for the proper functioning of the installation. The intent of this section is to bar any claim by contractor that the work done by purchaser has not been performed in such manner as to enable him to fulfill all the provisions of the contract.

5. *Alternates*

(a) The provisions contained in the alternate requisites section of this specification form a part hereof only when substituted by purchaser's order for the provisions contained in this specification.

(b) Where blanks have not been filled, or where an option is permitted and no preference stated, contractor's recommended practice shall be followed.

6. *Shipment of Material*

(a) Material shall be shipped to, care of, marked for Material shipped from contractor's factory at shall be shipped via and thence via to destination.

7. *Transportation*

(a) Purchaser will furnish transportation for men, necessary for the installation, over the following lines (*R-7-a):

1.
2.

(b) Purchaser will furnish transportation for tools and material, necessary for the installation, over the following lines (*R-7-b):

1.
2.

(c) Purchaser will furnish work train service for distribution of material.

*R-7-c.

(d) Purchaser will furnish work train service for erection of apparatus.

*R-7-d.

8. *Inspection of Installation*

(a) Contractor shall advise purchaser days in advance of the time installation will be completed and ready for final inspection. Purchaser will make inspection and tests within days after completion of the work.

9. *Tests*

(a) Contractor shall make such tests as may be necessary to demonstrate, to the satisfaction of purchaser, that the apparatus, as installed, is in accordance with the requirements of the specifications and contract. These tests, unless otherwise specified, shall include the tests referred to in section 9-b and shall be conducted in accordance with AAR Signal instructions for testing, where applicable, otherwise as directed by purchaser. Contractor shall provide such instruments and apparatus as may be necessary for making tests. Instruments and apparatus shall remain the property of contractor.

(b) Applicable inspection and test shall be made in accordance with Instructions for Inspection and Test of Signal Installation Before Placing in Service, Manual Part 189.

10. *Placing in Service*

(a) After receipt of written authority from purchaser, contractor shall place the installation in service under supervision of purchaser, and shall

* Alternate requisites section.

10. *Placing in Service*—Continued

leave competent men on duty for days thereafter.

*R-10-a.

(b) Signal aspects shall be displayed or changed only as authorized by purchaser.

11. *Completion*

(a) When installation is completed, apparatus and surface of the ground which has been affected by the installation, shall be left in a neat and clean condition.

12. *Clearances*

(a) Clearances shall conform to clearance diagram furnished by purchaser.

Detail Provisions

13. *Power Supply*

(a) Purchaser will furnish volts d-c or volts a-c, cycles, phase at points as shown on Drawing , dated , and of sufficient capacity to operate the plant properly.

14. *Power Plant*

(a) Power plant shall consist of

(b) shall be furnished by and installed by

(c) shall be furnished by and installed by

15. *Power House*

(a) Building shall be provided by , in accordance with Specification , dated , and Drawing , dated

16. *Auxiliary Power Plant*

(a) Auxiliary power plant when required shall consist of

(b) shall be furnished by and installed by

(c) shall be furnished by and installed by

17. *Switchboards and Equipment*

(a) Switchboards and equipment shall be in accordance with Specification for Switchboard and Equipment, Manual Part 153. *R-17-a.

18. *Switchboard Circuits*

(a) Contractor's recommended arrangement of circuits shall be followed, subject to modifications to meet purchaser's special requirements.

* Alternate requisites section.

19. *Generator*

(a) Alternating current generator shall be of kv-a. capacity at frequency, volts, phase and shall be in accordance with AIEE Standards.

(b) Direct current generator shall be of kw capacity at volts and shall be in accordance with AIEE Standards.

20. *Motor*

(a) Motor shall be h.p. capacity at frequency, volts, phase a-c; or volts d-c, and shall be in accordance with AIEE Standards.

21. *Motor-generator*

(a) Motor-generator shall be direct-connected, mounted on a cast-iron or arc-welded steel fabricated sub-base. *R-21-a.

22. *Air Compressors, Governors and Strainers*

(a) The following items shall be furnished by contractor (*R-22-a):

1. Compressors with capacity to provide for the maximum demand.

(a) Air compressors shall be electric motor driven, {one stage }
(compound)
with a capacity of cu. ft. delivery free air per minute, designed for air pressure of lbs. per sq. in. Motors shall be in accordance with AIEE Standards.

2. Stand-by compressor unit identical with section 22-a-1-a.

3. An air strainer, approved by purchaser, installed in each air intake pipe.

4. Automatic governors as required.

5. Interchange control panel for operating any compressor from any governor.

6. Starting and protective apparatus, as approved by purchaser.

(b) Foundations for compressors shall be provided by purchaser.

23. *Air Reservoirs*

(a) Auxiliary air reservoirs for collection of condensation shall be furnished and installed, as required, for condensers, for each low spot in the main air pipe and at such other locations as shall be designated by purchaser. Each reservoir shall be equipped with stop cock and blow-off pipe extending from bottom of reservoir.

(b) Extra large reservoirs called expansion tanks shall be used to provide a stand-by air supply. These reservoirs shall be properly equipped for drainage. *R-23-b.

(c) All steel reservoirs shall be designed for 150 lbs. per sq. in. working pressure and manufactured and tested in accordance with ASME Code for Unfired Pressure Vessels. Cast-iron reservoirs shall be tested to a hydrostatic pressure of 300 lbs. per sq. in.

24. *Air Pipe Lines*

(a) Air lines shall be of extra strong, galvanized steel pipe in accordance with ASTM current Specification A120 and free from zinc oxide or other foreign material that may scale off. *R-24-a.

* Alternate requisites section.

24. *Air Pipe Lines*—Continued

(b) Each length of pipe larger than $\frac{3}{4}$ in. diameter shall be provided with two metallic thread protectors and one extra heavy galvanized recessed coupling, shipped separately in boxes. Pipes of lesser diameter may be shipped in bundles with one end protected with heavy burlap and the extra heavy galvanized recessed coupling turned on the pipe hand tight.

(c) Fittings.

1. Fittings (elbows, unions, valves, etc.) around the compressor plant and in pits that are accessible for inspection, maintenance, etc., shall be for at least 125 lbs. working pressure.

2. Fittings that are buried shall be AAR Mechanical Division type for 300 lbs. working pressure.

3. Gate valves shall have brass seat and rising stem. *R-24-c-3.

4. Stop cocks and screw unions for $\frac{3}{4}$ in. pipe and smaller shall have brass seats. *R-24-c-4.

5. Flexible connections shall be best quality $\frac{1}{2}$ in. reinforced or armored hose having 3 in. nipple inserted and securely fastened in each end and having not less than 16 in. of hose between the ends of the nipples. Complete connection shall be capable of withstanding a working pressure of 150 lbs. per sq. in.

6. Branch air line shall be taken from the top of the main air line, the connection being made by means of two street or service "L's" so arranged as to form a hinged joint to provide for expansion or by means of flexible hose.

7. Expansion joints for pipes 2 inches in diameter or larger shall have an iron body, a brass or iron sleeve and allowance for 6 in. expansion. *R-24-c-7.

8. Expansion joints shall be placed in the main air line not more than 500 ft. apart where pipe is located above ground and 1500 ft. where pipe is located underground. *R-24-c-8.

9. Main air line, when above ground, shall be securely anchored midway between each pair of expansion joints and at ends of line.

10. Each branch line shall contain a brass cock and union at or near its connection with the main and, if underground, shall be adequately protected and accessible.

11. Check valves shall be installed in main air line as designated by purchaser.

12. Approved type of air filter shall be installed between each branch line and pneumatically operated unit. *R-24-c-12.

(c) Main air line shall be in good surface and so graded that condensation will run into suitable drain tanks. Main reservoirs shall be connected in series with the main air line and be provided with by-pass of the same size as the main air line. Flanges, unions, gate valves, etc., shall be provided so that main reservoirs may be removed without interrupting the flow of air through the by-pass.

(e) Pipe line installed in clean sand or gravel shall have no special protection. *R-24-e.

(f) Pipe line installed in cinder or slag ballast shall be wrapped with approved tape and surrounded by 4 in. of sand or loam.

* Alternate requisites section.

24. *Air Pipe Lines*—Continued

(g) Air line when placed above the ground parallel to the track shall not be placed nearer than 6 ft. from the gage side of the rail, except by permission of purchaser.

(h) Local conditions shall determine the height of the main air line when above ground but in all cases the bottom of the pipe shall be not less than 6 in. above the top of the ground, except by permission of purchaser.

(i) Supports for main air line shall be placed not more than 10 ft. apart.

(j) Red lead, graphite or equivalent shall be applied to the pipe threads and only after pipe connections have been started when pipe is coupled.

(k) Each length of pipe and the fittings shall be free from dirt and scale before being coupled in the line, and care shall be exercised that no dirt gets in the line at any time. Pipe lines shall be blown out before being connected to any apparatus.

(l) Galvanizing shall be in accordance with Specifications for Metallic Coating of Metals, Manual Part 63.

(m) Alcohol feeder of type approved by purchaser shall be furnished when specified.

(n) Connections for emergency air supply, as approved by purchaser, shall be provided when specified.

(o) Air pressure indicator of a type approved by purchaser shall be provided when specified.

(p) Recording gage of a type approved by purchaser shall be provided when specified.

25. *Condensers*

(a) Condensers shall be of the atmospheric type. *R-25-a.

(b) Condensers shall be located as close to the compressor as practicable. They shall have a radiating surface of at least 1 sq. ft. per cu. ft. per minute of compressor air demand. Condensers shall be in accordance with specifications and shall be furnished by and installed by

26. *Transformers*

(a) Oil-cooled transformer shall be in accordance with Specification 84, Manual Part 165.

(b) Air-cooled transformer shall be in accordance with Specification 83, Manual Part 164.

(c)

27. *Rectifiers*

(a) Rectifiers shall be of type.

(b) Rectifiers shall be in accordance with the following specifications, where applicable:

1. Copper-Oxide Rectifiers and Valves—Specification 166, Manual Part 139.

2. Tantalum Rectifiers and Valves—Specification 189, Manual Part 47.

3. Selenium Rectifiers—Specification 229, Manual Part 243.

* Alternate requisites section.

27. *Rectifiers—Continued*

- (c) Track circuit rectifier characteristics.
 - 1. A-C volts, cycles
 - 2. D-C volts maximum, minimum, amperes maximum, minimum, for:
 - (a) Operating track circuits direct.
 - (b) Charging cells, type storage battery.
 - (c) Use in multiple with cells, ampere-hour, type primary battery.
- (d) Line circuit rectifier characteristics.
 - 1. A-C volts, cycles
 - 2. D-C volts maximum, minimum, amperes maximum, minimum, for:
 - (a) Operating line circuits direct.
 - (b) Charging cells, type storage battery.
 - (c) Use in multiple with cells, ampere-hour, type primary battery.
- (e) Signal operating rectifier characteristics.
 - 1. A-C volts, cycles
 - 2. D-C volts maximum, minimum, amperes maximum, minimum, for:
 - (a) Operating signals direct.
 - (b) Charging cells, type storage battery.
 - (c) Use in multiple with cells, ampere-hour, type primary battery.
- (f) rectifier characteristics.
 - 1. A-C volts, cycles
 - 2. D-C volts maximum, minimum, amperes maximum, minimum, for:
 - (a)
 - (b) Charging cells, type storage battery.
 - (c) Use in multiple with cells, ampere-hour, type primary battery.

28. *Batteries*

- (a) Batteries shall be in accordance with the following specifications where applicable:
 - 1. Nickel, Iron, Alkaline Storage Battery—Specification 49, Manual Part 15.
 - 2. Lead Acid Stationary Storage Battery (Plates of Pure Lead)—Specification 58, Manual Part 19.
 - 3. Lead Acid Stationary Storage Battery (Plates of Alloy Composition)—Specification 158, Manual Part 117.
 - 4. Lead Acid Stationary Storage Battery (Plates of Composite Structure)—Specification 53, Manual Part 18.
 - 5. Specification for Electrolyte, Manual Part 13.
 - 6. Type "A" Copper-Oxide Caustic Soda Primary Cell—Specification 87, Manual Part 6.
 - 7. Type "B" Copper-Oxide Caustic Soda Primary Cell—Specification 171, Manual Part 4.

28. *Batteries—Continued*

8. Air Depolarized Primary Cell (Renewable Type)—Specification 172, Manual Part 16.

(b) Main operating batteries shall consist of sets cells of type ampere-hour capacity.

(c) Local operating batteries shall consist of:

1. sets cells of type ampere-hour capacity.

2. sets cells of type ampere-hour capacity.

(d) Track batteries shall be of cells of type ampere-hour capacity.

(e) Line batteries shall be of cells of type ampere-hour capacity.

(f) Supports for batteries in interlocking or control station shall be furnished in place by the and shall conform to Drawing dated

(g) Storage battery shall be charged to rated capacity by before placing in service.

(h) The shall furnish with each set of main battery, one hydrometer and one battery thermometer.

(i) Installation of various types of batteries shall be in accordance with Instructions for Batteries and Cells, Manual Parts 14 and 17, respectively.

29. *Interlocking or Control Station*

(a) Building shall be provided by, in accordance with Specification, dated, and Drawing, dated

30. *Interlocking Machine*

(a) Interlocking machine shall be in accordance with the following:

1. Electric Interlocking Machine—Specification 76, Manual Part 85.

2. Electro-Mechanical Interlocking Machine—Specification 134, Manual Part 193.

3. Mechanical Interlocking Machine, S. & F. Locking—Specification 75, Manual Part 82.

4. Electro-Pneumatic Interlocking Machine.—See Electric Interlocking Machine, Specification 76, Manual Part 85.

31. *Control Machine*

(a) Control machine shall be in accordance with the following:

1. Control Machines Other Than for Classification Yards—Specification 150, Manual Part 98.

2.

32. *Building Lighting*

(a) Lighting shall be in accordance with Specification, dated, and Drawing, dated

(b) Wiring, fixtures, accessories and installation for electric lighting shall be in accordance with rules of the National Board of Fire Underwriters and requirements of local authorities.

33. *Lightning Arresters*

(a) Line arresters, type, shall meet AIEE requirements and shall be installed as shown on circuit drawings.

(b) Low-voltage arresters, type, shall meet the requirements of Specification 52, Manual Part 95, and shall be installed as shown on circuit drawings.

(c) Arrester grounds shall be in accordance with Specification 60, Manual Part 92. Contractor's liability is limited to ground rods per location.

(d) Arresters for code lines shall be particularly sensitive and provide insulation resistance equivalent to an open space or air gap arrester.

(e) Arresters of design shall be installed as shown on circuit drawings.

34. *Wires and Cables*

(a) Wires and cables shall be in accordance with the following specifications:

1. Line Wire—Specification 168, Manual Part 173.
2. Specification for Galvanized Steel Strand, Manual Part 184.
3. Copper-Covered Steel Guy and Messenger Strand—Specification 173, Manual Part 69.
4. Insulated Wire, A.V.C.—Specification 192, Manual Part 187.
5. Insulated Wire—Specification 111, Manual Part 186.
6. Stranded Aluminum Line Wire—Specification 54, Manual Part 24.
7. Braid-Covered Cable—Specification 89, Manual Part 25.
8. Lead Sheathed Cable, Submarine—Specification 90, Manual Part 26.
9. Lead Sheathed Cable, Non-Armored—Specification 91, Manual Part 28.
10. Lead Sheathed Cable, Armored—Specification 145, Manual Part 20.
11. Neoprene Sheathed Cable with Outer Covering—Specification 161, Manual Part 36.
12. Neoprene Sheathed Cable—Specification 240, Manual Part 249.
13.
14.

35. *Size of Wire*

(a) Wire shall be of sufficient size to permit operation of switch and signal mechanisms in accordance with this specification.

(b) Single-conductor wires external to the interlocking or control station or instrument housings shall be not smaller than No. 14 AWG. Single-conductor wires within the station or housings shall be not smaller than No. 16 AWG.

(c) Wires in cable external to the interlocking or control station shall be not smaller than No. 16 AWG.

(d) Line wires shall be not smaller than No. 10 AWG for hard-drawn copper or copper alloy, or No. 12 AWG for copper-covered steel.

(e) In cables, spare wires shall be provided as designated by purchaser.

35. *Size of Wire—Continued*

(f) Size and description of circuit conductors shall be as follows:

	Mfgr. desig. (a)	AWG (b)	Material (c)	Thickness of insulation (d)	Braid (e)	Tape (f)
1. Track transformers or batteries to rail.....						
2. Relay to each rail.....						
3. Fouling shunt connec- tions.....						
4. Series track connections						
5. Switch circuit controller shunt connections.....						
6. Line drops.....						
7. Power line drops.....						
8. Signal wires.....						
9. Switch wires.....						
10. Ground wires.....						
11. Signal lighting wires.....						
12. Inside wiring (cases, etc.).....						
13. Aerial wire.....						
14. Transmission line.....						
15. CTC line.....						
16. Relay leads.....						
17. Aerial cables.....						
18. Underground cables.....						
19. Submarine cables.....						
20.						

36. *Wiring*

(a) Wiring shall be installed in accordance with Instructions for Wiring, Manual Part 84.

(b) Lead cable underground without other mechanical protection shall be placed in conduit.

37. *Overload Devices*

(a) Fuses shall be:

	Type	Voltage	Capacity
1.			
2.			

(b) Fuse clips shall be mounted on an insulating base of fireproof material.

(c) Circuit breakers shall be:

	Type	Voltage	Capacity
1.			
2.			

(d) Fuses or circuit breakers shall be installed according to contractor's standard practice as approved by purchaser. *R-37-d.

(e) Fuses or circuit breakers outside of buildings shall be enclosed in weatherproof housings.

(f) Entrance fuses in buildings shall be enclosed in fireproof compartments.

* Alternate requisites section.

38. *Signals*

- (a) Signals shall be of type.
(b) Signals shall be in accordance with the following specifications and drawings, where applicable:

1.
2. Color Light Signal—Specification 80, Manual Part 146, or Specification 157, Manual Part 93.
3. Position Light Signal—Specification 81, Manual Part 147.
4. Color Position Light Signal—Specification 162, Manual Part 50.
5. Bolt and Clamp for 5-Inch Masts—Drawing 1083.
6. Filler Block—Drawings, dated
7. Ladders—Drawings 1432 and 1435.
8. Ladder Foundations—Drawing 1052.
9. Base for Mast—Drawings 1059, 1178, 1447, 1448, 1449 and 1690.
10. Details and Assembly of Marker Lights—Drawing, dated
11. Grade Signal Marker—Drawing 1612.
12. Take Siding Indicator—Drawings 1513, 1515 and 1516.

- (c) Signals shall be aligned to give the best view to approaching trains as determined by purchaser.

- (d) Signals and fittings not otherwise specified shall be in accordance with manufacturer's recommended design subject to approval of purchaser.

39. *Numerals, Letters and Brackets*

- (a) Numerals, letters and brackets shall conform to Drawings 1557 and 1558. *R-39-a.

40. *Signal Lighting*

- (a) The maximum allowable drop in potential on circuits to any lamp shall be 10 percent.

- (b) Alternating current distribution at volts, cycles shall be used. *R-40-b.

- (c) Where primary battery is used for lighting, voltage regulators shall be used. *R-40-c.

- (d) Incandescent electric lamps shall be in accordance with Specification 51, Manual Part 91, and shall be Item No. of the Appendix thereto.

41. *Special Circuits*

- (a) Special circuit requirements, in detail, are as follows:

1.
2.

42. *Roundels, Lenses and Glass Slides*

- (a) Roundels, lenses and glass slides shall be in accordance with Specification 69, Manual Part 136.

- (b) The following colors shall be used:

	Indication	Color
1.		
2.		

* Alternate requisites section.

43. *Signal Bridges*

- (a) Signal bridges shall conform to Drawing, dated

44. *Switch Operating Mechanism*

- (a) Switch operating mechanism shall be in accordance with the following:

1. Electro-Pneumatic Switch Operating Mechanism—Specification 152, Manual Part 30.
2. Electric Motor Switch Operating Mechanism—Specification 101, Manual Part 104.

- (b) The distance from track and the location of the switch operating mechanism shall be as designated by purchaser.

45. *Switch Adjustments*

- (a) Switch adjustments shall conform to Drawing, dated

- (b) Switches, derails and movable point frogs shall be provided with switch adjustments fastened to the No. 1 switch rod.

46. *Mechanical Connections*

- (a) Arrangement and support of connections shall be such that switch, derail or movable point frogs can be stopped by placing an obstruction between point and stock rail at any point of stroke without breaking or bending such connections.

- (b) The operating or the lock rods shall be of sufficient strength to alone and independently hold the switch points in position.

47. *Relays*

- (a) Time element relays shall be in accordance with Specification 197 or 202, Manual Parts 1 and 2.

- (b) Direct current relays.

1. Tractive armature direct current neutral relays shall be in accordance with the following specifications:

- (a) Two or More Contact Fingers—Specification 105, Manual Part 123.

- (b) Two Contact Fingers—Specification 154, Manual Part 101.

- (c) Biased Neutral—Specification 228, Manual Part 232.

- (d) Interlocking—Specification 186, Manual Part 105.

- (e) Plug-In Type—Specification 204, Manual Part 77.

- (f) Flasher Type—Specification 185, Manual Part 143.

- (g) For Non-Vital Circuits—Specification 224, Manual Part 228.

- (h) Detachable Type for Use in Non-Vital Circuits—Specification 180, Manual Part 145.

2. Tractive armature direct current polarized relays shall be in accordance with Specification 165, Manual Part 137.

3. Tractive armature direct current retained neutral polarized relays shall be in accordance with Specification 221, Manual Part 231.

- (c) Alternating current relays.

1. Alternating Current Induction Type Relay—Specification 78, Manual Part 122.

2. Alternating Current Power Transfer Relay—Specification 148, Manual Part 53.

47. *Relays—Continued*

(d) Code relays and transmitters.

1. Alternating Current Motor-Operated Code Transmitter—Specification 210, Manual Part 214.

2. Direct Current Code Transmitter—Specification 211, Manual Part 215.

3. Direct Current Code-Following Polar Relay—Specification 212, Manual Part 216.

(e) Other types of relays.

1. Other types of relays shall be as follows:

(a)

(b)

48. *Time Releases*

(a) Mechanical time releases shall be installed as required by purchaser and shall be in accordance with Specification 128, Manual Part 129.

(b) Setting of time releases shall be in accordance with Instructions for Time Releases Applied to Signal Apparatus, Manual Part 128. *R-48-b.

49. *Reactors and Resistors*

(a) Reactors shall be in accordance with Specification 104, Manual Part 121.

(b) Resistors shall be in accordance with Specification 106, Manual Part 135.

50. *Circuit Controllers*

(a) Switch circuit controllers shall be in accordance with Specification 95, Manual Part 49. *R-50-a.

(b) Switch circuit controller connections shall conform to Drawings 1255, 1256, 1271 and 1272. *R-50-b.

(c) Switch circuit controllers shall be connected to the normally closed switch point.

(d) Mechanical lever circuit controllers shall be in accordance with Specification 138, Manual Part 197.

(e) Movable bridge circuit controllers shall be in accordance with Specification 130, Manual Part 48.

(f) circuit controllers shall be in accordance with
.....

51. *Locks*

(a) Electric locks for interlocking machines shall be in accordance with Specification 99, Manual Part 96.

(b) Electric switch lock shall be in accordance with Specification 198, Manual Part 109.

(c) Mechanical switch locks shall be

* Alternate requisites section.

52. *Indicators, Indication Lights and Illuminated Track Diagram*

(a) Indicators, indication lights and illuminated track diagram shall be as follows:

1. Indicators type.
2. Indication lights design.
3. Illuminated track diagram design shall be installed in accordance with Drawing, dated

(b) Switch indicators shall be in accordance with

53. *Annunciators, Annunciator Bells*

(a) Annunciators shall be of the following type:

1.
2.

(b) Annunciator bells shall be of the following type:

1.
2.

54. *Capacitors for Power Factor Improvement*

(a) Capacitors for power factor improvement shall be in accordance with Specification 160, Manual Part 100.

55. *Automatic Train or Time Recorder*

(a) Automatic train or time recorder, when installed, shall be in accordance with purchaser's requirements.

56. *Track Circuits*

(a) Track circuits shall be of type and in accordance with Requisites for Track Circuits, Manual Part 59.

(b) The overlay track circuits shall be

57. *Bonding*

(a) Track circuit bonding shall be in accordance with Specification 135, Manual Part 22.

58. *Insulated Rail Joints*

(a) Insulated joints shall be type and for section, lb. rail with hole drilling.

(b) Insulated joints shall be installed in accordance with Instructions for Insulated Rail Joints, Manual Part 133.

(c) Insulated joints shall be located as shown on Drawings 1634, 1635, 1636, 1637 and 1638.

59. *Bootlegs*

(a) Bootlegs shall conform to Drawing, dated

60. *Track Circuit Connectors*

(a) Track circuit connectors shall conform to Drawings 1047, 1048, 1631 or 1632. *R-60-a.

* Alternate requisites section.

61. *Fouling Circuits*

- (a) Fouling protection of turnouts and crossovers shall conform to Form 7004, Manual Part 206. *R-61-a.

62. *Impedance Bonds*

- (a) Impedance bonds shall be in accordance with Specification 74, Manual Part 67.
(b) Impedance bond compound shall be in accordance with Specification 77, Manual Part 111.
(c) Impedance bond oil shall be in accordance with Specification 217, Manual Part 222.

63. *Coded System Track Circuit Unit*

- (a) Coded system track circuit unit shall be in accordance with the following:
1. Non-Resonant—Specification 219, Manual Part 202.
 2. Resonant—Specification 207, Manual Part 213.

64. *Coded System*

- (a) Coded system filters shall be in accordance with the following:
1. Low Pass—Specification 225, Manual Part 229.
 2. Voice Pass—Specification 233, Manual Part 240.
 3. Voice and Carrier Pass—Specification 235, Manual Part 242.
 4. Voice and Type H Pass—Specification 234, Manual Part 241.
 5. Other filters shall be as follows:
(a)
(b)

65. *Communication System*

- (a) Telephone system shall be in accordance with Communication Manual Specifications.
(b) Telephones or telephone jacks shall be located in suitable housings at switch and signal locations as specified by purchaser.
(c) Loud speaker equipment shall be installed as specified by purchaser.
(d) Selector equipment shall be installed as specified by purchaser.
(e) Teletype system shall be installed as specified by purchaser.
(f) system shall be installed as specified by purchaser.

66. *Control and Communication Circuits*

- (a) Purchaser will designate which circuits shall be single wire, single break, or double wire, double break, and furnish the following typical circuit plans which contractor is to follow, or where contractor's standard practice or plans are followed, purchaser will approve plans before work is started:
1. Signal control.
 2. Signal indication.
 3. Signal lighting.
 4. Switch control.
 5. Switch indication.
 6. Approach locking.

* Alternate requisites section.

66. *Control and Communication Circuits—Continued*

7. Traffic locking.
8. Sectional locking.
9. Route locking.
10. Route locking with sectional release.
11. Time locking.
12. Light indication.
13. Track.
14. Communication.
15.
16.

67. *Carrier Systems for Control of Remote Sections*

- (a) Purchaser will designate territory limits of carrier circuits.
- (b) Carrier equipment shall be installed as specified by purchaser.
- (c) Carrier equipment shall be in accordance with manufacturer's specifications, modified to meet purchaser's requirements.
- (d) Carrier channel power levels, frequencies and transpositions shall be in accordance with Recommendations on Carrier Control Systems Covering Directions, Frequencies, Energy Levels and Method of Handling, Manual Part 144.

68. *Line Material.*

- (a) Crossarms and pole line hardware shall be in accordance with Communication Manual specifications.
- (b) Insulators for distribution system shall be of type, material.
- (c) Insulators for low-voltage circuits shall be of type, material.
- (d) Pin type porcelain insulators shall be in accordance with Specifications for Pin Type Insulators, Manual Part 160.

69. *Instrument Housings*

- (a) Instrument housings shall conform to the following drawings:
 1. Cable Post—Drawing 1192.
 2. Relay Box Inlet Bracket—Drawing, dated
 3. Relay Box Linings and Terminal Boards—Drawing, dated
 4. Relay Box Fittings—Drawing, dated
 5. Relay Box and Cable Post Mountings—Drawing, dated
 6. Steel Instrument House—Drawing 1602.
 7. Steel Instrument Case—Drawing 1601, 1626, 1627 or 1628.
 8. Concrete housing shall conform to Drawing, dated
 9. Relay racks shall conform to Drawing, dated
 10.

70. *Battery Housings*

- (a) Battery housings shall conform to Drawing, dated
- (b) Concrete battery boxes shall conform to Drawings 1266, 1267, 1268 and 1269.
- (c) Battery racks shall conform to Drawing, dated

71. *Junction Boxes*

- (a) Junction boxes shall conform to Drawing, dated
- (b) Junction boxes shall be located as shown on Drawing, dated

72. *Terminal Boxes*

- (a) Terminal boxes shall conform to Drawing, dated

73. *Conduits*

- (a) Conduits shall be in accordance with the following:
 - 1. Specification for Fibre Conduit, Manual Part 37.
 - 2. Specification for Communication Underground Conduit Construction, Manual Part 38.
 - 3. Specification for Steel Pipe Conduit, Manual Part 39.
 - 4. Specification for Wrought Iron Pipe Conduit, Manual Part 40.

74. *Wire Chases*

- (a) Wire chases and conduits within the interlocking or control station shall be of fireproof construction. Provision shall be made by purchaser in the walls and floors for proper housing of all wires between machine and relay case and between relay case and first pull box outside of station.

75. *Padlocks*

- (a) Purchaser's padlocks shall be furnished by and shall be used where specified by purchaser.

76. *Switch-rod Insulation*

- (a) Switch-rod insulation shall conform to Drawing 1055. *R-76-a.

77. *Pipe-line Insulation*

- (a) Pipe-line insulation shall conform to Drawing 1094. *R-77-a.

78. *Fibre Insulation*

- (a) Fibre insulation shall be in accordance with Specification 13, Manual Part 58.

79. *Front Rods*

- (a) Front rods shall be of the solid adjustable type. *R-79-a.

80. *Lock Rods*

- (a) Lock rods shall conform to Drawing 1587. *R-80-a.
- (b) Notches in lock rods and ends of plungers or locking dogs shall have square edges.
- (c) Lock rods shall run direct from front rods or switch lugs into lock stands.

81. *Gage and Butt Plates*

- (a) Gage plates shall be of steel, 1 in. by 7 in. Steel shall be in accordance with Specifications for Various Types of Steel, Manual Part 154, section 1.

* Alternate requisites section.

81. *Gage and Butt Plates—Continued*

(b) Gage plates shall be insulated. Insulation shall conform to Drawing 1373.

(c) Butt plates shall be of steel, 1 in. by 3 in. by 7 in., drilled for three $\frac{3}{4}$ in. rivets, middle rivet staggered. Steel shall be in accordance with Specifications for Various Types of Steel, Manual Part 154, section 1. *R-81-c.

(d) Not less than one gage plate shall be used for each switch and split point derail and shall be located on point tie. *R-81-d.

(e) Not less than four gage plates shall be used for each set of movable point frogs and shall be so located that one plate will be placed on point tie and one on first tie back of point tie for each pair of points. *R-81-e.

(f) Gage plates shall be fitted in place and securely fastened to the ties with drive spikes conforming to Drawing 1296. *R-81-f.

(g) Ties supporting lifting type derails shall be equipped with gage plates.

(h) Gage plates shall be drilled to provide for spiking and holding points of switches, derails and movable point frogs securely to stock rail in either position.

(i) Contractor shall ascertain from purchaser correct gage of track before fitting gage plates to any switch, derail or movable point frog.

82. *Rail Braces*

(a) Rail braces shall be adjustable of the type. *R-82-a.

(b) Rail braces shall be used on gage or switch plates.

83. *Tie Straps*

(a) Tie straps shall be of steel, $\frac{3}{4}$ in. by $2\frac{1}{2}$ in. Steel shall be in accordance with Specifications for Various Types of Steel, Manual Part 154, section 1.

(b) Tie straps shall be used at all switches, derails and movable point frogs, to tie all crank, rocking shaft, switch point and intermediate ties together, placed, if practicable, 10 in. from base of rail, and fastened to each tie with one drive spike $\frac{3}{4}$ in. diameter by not less than $4\frac{1}{2}$ in. long.

84. *Bolts, Screws and Washers*

(a) Bolts and nuts, and machine screw threads shall be in accordance with Specifications for Bolts, Nuts and Threads, Manual Part 17.

(b) Hexagon head cap screws, slotted head cap screws, square head set screws and slotted headless set screws shall be in accordance with current American Standard B18.6.2.

(c) Socket head cap screws and socket head set screws shall be in accordance with current American Standard B18.3.

(d) Drive spikes shall conform to Drawing 1296.

(e) Drive spikes shall be driven into holes previously filled with creosote oil. These holes shall be bored as specified on Drawing 1296.

(f) Cast washers shall conform to Drawing 1458 or be of a type approved by purchaser.

(g) Plain and lock washers shall be in accordance with Specifications for Plain and Lock Washers, Manual Part 35.

* Alternate requisites section.

84. *Bolts, Screws and Washers—Continued*

(h) Plain or cast washers shall be used under boltheads, nuts and screws where they come in contact with wood.

(i) Spring lock washers shall be used under nuts as follows:

1.
2.

85. *Foundations*

(a) Purchaser will, in the presence of contractor's representatives, designate the location of each foundation.

(b) Foundations shall be rigid, level and parallel to track.

(c) Elevation and distance of foundations from track shall be in accordance with purchaser's standard practice.

(d) Foundations for ground mast signals and instrument cases shall conform to Drawing 1107, 1259, 1560, 1561, 1579, 1580, 1581 or 1694. *R-85-d.

(e) Foundations not otherwise specified shall be in accordance with purchaser's standard.

(f) Concrete foundations shall be allowed to properly set before any apparatus is connected thereto or placed thereon.

(g) Foundations shall be so constructed that apparatus can be removed without disturbing foundations.

(h) Dimensions for foundations shall be applicable to level and solid ground. Purchaser and contractor shall jointly decide when deviations from specified sizes are necessary.

(i) Foundations shall be provided by, in accordance with Specification, dated, and Drawing, dated

86. *Anchor Bolts*

(a) Anchor bolts for ground mast signals shall conform to Drawing 1107, 1259, 1560, 1561, 1579, 1580, 1581 or 1694.

(b) Anchor bolts for other foundations shall be in accordance with purchaser's standard.

(c) Threads of anchor bolts shall not be embedded in concrete foundations.

(d) Bolt holes in signal base castings shall be filled with pitch or equivalent waterproof and rust-resisting compound.

87. *Concrete*

(a) Concrete shall be 1-2-4 mixture and in accordance with Specification, dated *R-87-a.

88. *Painting*

(a) Painting shall be in accordance with Instructions for Painting, Manual Part 110.

89. *Special Items*

- (a)
-

* Alternate requisites section.

Alternate Requisites

R-3-d.

Framed track diagram shall be furnished in place by contractor, in interlocking station.

R-3-e.

Manipulation chart shall be furnished in place by contractor, in interlocking station.

R-3-g.

After award of the contract and before work is begun, purchaser shall furnish the following drawings as scheduled by purchaser:

1. Track plan showing instrument housing, switches, signals and track circuits, within days.
2. Detail circuit plans, within days.
3. Instrument case wiring plans, within days.
4. Cable diagrams, within days.
5. Pole line diagrams, within days.

R-7-a.

Contractor will furnish transportation for men, necessary for the installation, over the following lines:

1.
2.

R-7-b.

Contractor will furnish transportation for tools and material, necessary for the installation, over the following lines:

1.
2.

R-7-c.

Purchaser will not furnish work train service for distribution of material.

R-7-d.

Purchaser will not furnish work train service for erection of apparatus.

R-10-a.

Purchaser will place the installation in service in the event that he does not authorize contractor to do so within days after completion of the work to purchaser's satisfaction.

R-17-a.

Switchboard shall be in accordance with

R-21-a.

Motor-generator shall not be direct-connected.

R-22-a.

The following items shall not be furnished by contractor:

1. Compressors.
2. Stand-by compressors.
3. Air strainers.
4. Automatic governors.
5. Interchange control panel.
6. Starting and protective apparatus.

Alternate Requisites—Continued

R-23-b.

Extra large reservoirs called expansion tanks to provide a stand-by air supply shall not be used.

R-24-a.

Air lines shall be of extra strong, galvanized wrought iron in accordance with ASTM current Specification A 72 for underground service, and extra strong, galvanized steel pipe in accordance with ASTM current Specification A 120 for service above ground and free from zinc oxide or other foreign material that may scale off.

R-24-c-3.

Gate valves shall have

R-24-c-4.

Stop cocks and screw unions for $\frac{3}{4}$ in. pipe or smaller shall be.....

R-24-c-7.

Expansion joints for pipes 2 inches in diameter or larger shall have

R-24-c-8.

Expansion joints shall be placed in the main air line not more than ft. apart where pipe is located above ground and ft. where pipe is located underground.

R-24-c-12.

Air filter shall not be furnished.

R-24-e.

All pipe shall have approved protection.

R-25-a.

Condensers shall be of the type.

R-37-d.

Fuses or circuit breakers shall be installed as follows:

R-39-a.

Numerals, letters and brackets shall conform to Drawing, dated

R-40-b.

Direct current distribution at volts shall be used.

R-40-c.

Where primary battery is used for lighting, voltage regulators shall not be used.

R-48-b.

Setting of time releases shall be

R-50-a.

Switch circuit controllers shall be

Alternate Requisites—Continued

R-50-b.

Switch circuit controller connections shall conform to

R-60-a.

Track circuit connectors shall conform to Drawing, dated

R-61-a.

Fouling protection of turnouts and crossovers shall conform to Drawing, dated

R-76-a.

Switch-rod insulation shall conform to Drawing, dated

R-77-a.

Pipe-line insulation shall conform to

R-79-a.

Front rods shall be

R-80-a.

Lock rods shall conform to

R-81-c.

Butt plates shall be

R-81-d.

Gate plates shall not be used on switches and split point details.

R-81-e.

Not less than gage plates shall be used for each set of movable point frogs and shall be so located that one plate will be placed on point tie.

R-81-f.

Gage plates shall be fitted in place and securely fastened to the ties with

R-82-a.

Rail braces shall be non-adjustable of the type.

R-85-d.

Foundations for ground mast signals and instrument cases shall conform to Drawings, dated

R-87-a.

Concrete shall be mixture in accordance with Specification, dated

Exhibit 10-E

(Revision and Consolidation of AAR Signal Section Requisites for Switch
Operating Mechanism for Slow Speed Train Movements and
Specifications 247-49 and 243-49)
AAR SIGNAL SPECIFICATION 274-62

SWITCH OPERATING MECHANISM FOR YARDS

1. *Purpose*

(a) This specification is for the purpose of providing for power-operated switch mechanism for yards. It sets forth specific detail requirements representing modern signal practice recommended for new installations and for replacement on existing installations when general renewal or replacement becomes desirable.

2. *Requisites, Specifications and Drawings*

(a) Requisites, specifications and drawings referred to in the body of this specification form an essential part hereof.

(b) Manufacturer shall furnish with his tender, drawings forming an essential part thereof.

3. *Tender*

(a) The tender shall be for a product meeting the requirements of this specification in its entirety.

4. *Purchaser's Order Requirements*

(a) The following additional requirements will be shown on purchaser's order:

1. Electric switch mechanism for operation on:

(a) volts, d-c, or

(b) volts, cycles.

2. Electro-pneumatic switch mechanism for operation on:

(a) Between and lbs. per sq. in. air pressure.

5. *Alternates*

(a) The provisions contained in the alternate requisites section of this specification form a part hereof only when substituted by purchaser's order for the provisions contained in this specification.

6. *Material and Workmanship*

(a) Material and workmanship shall be first-class in every respect.

7. *Design*

(a) Mechanism shall be so designed as to permit its being secured in fixed relation to the track.

(b) Switch mechanism shall be so designed that trailing movements through the switch points will not damage the mechanism.

(c) The mechanism shall be enclosed in a substantial metallic weather-proof case, the cover of which shall be removable and equipped with suitable

7. Design—Continued

fasteners for application of purchaser's padlock, and when open shall provide access to all parts.

(d) Mechanism case shall be provided with wire entrance of ample size, conveniently located for access to binding posts, equipped with adapter castings and flexible conduit arranged to protect wires from mechanical injury. *R-7-d.

(e) Moving parts shall work freely, without lost motion, and provision shall be made for proper and convenient lubrication.

(f) Mechanism shall be so designed that it may be used for either right or left-hand operation.

(g) Mechanism shall be designed to give at least $5\frac{1}{2}$ in. throw of the switch operating rod. Mechanism shall give complete operation in not more than 1.2 seconds. *R-7-g.

(h) Mechanism shall be capable of exerting a force on the No. 1 rod with the switch full normal or full reverse of not less than 1000 lbs.

(i) Means shall be provided for manual operation of the switch mechanism. *R-7-i.

(j) Means shall be provided to disconnect power before manual operation. *R-7-j.

(k) Mechanism shall be so designed that when the switch points are in the closed position, it will hold them in that position when power is off. *R-7-k.

(l) Mechanism shall be so designed that it can be reversed from any position in the stroke or be obstructed without damage.

(m) Means shall be provided to indicate that mechanism throw has been completed.

(n) Electric mechanism.

1. Motor.

(a) Motor shall be enclosed in a substantial metallic, weather-proof case. The cover when open shall permit access to terminals, commutator and brushes or their equivalent.

(b) The motor shall be capable of delivering, without injury, the torque necessary for the most severe operating conditions.

(c) Motor shall be attached to, and form a part of, the mechanism and shall be removable therefrom.

(d) Case shall be provided with wire entrance of ample size, conveniently located for access to binding posts, and arranged to protect wires from mechanical injury.

(e) Motor shall be designed for voltage and frequency as specified in purchaser's order requirements.

2. Contact members shall be made of corrosion-resisting metal of sufficient mechanical strength and current-carrying capacity to satisfactorily operate in connection with the circuits used.

3. Movements of the contact members shall be such as will insure a wiping contact.

4. Bearings.

(a) Bearings shall be of ample dimensions to insure reasonable durability.

* Alternate requisites section.

7. *Design—Continued*

(b) Motor shall be designed to prevent lubricant from bearings getting on brushes, commutator or windings.

(c) Exposed oil holes shall be provided with weatherproof oil cups or covers.

5. *Wiring.*

(a) Internal wiring shall be neatly arranged and placed in ducts or channels of ample capacity forming an integral part of the apparatus.

(b) Wire for internal wiring shall be insulated and of strands of tinned or leaded copper not larger than No. 27 AWG wire. The aggregate cross-section of the strands shall be not less than No. 14 AWG wire. Wire eyelet or other suitable terminal shall be provided at each end of connecting leads.

(o) *Electro-pneumatic mechanism.*

1. Mechanism shall be designed to operate on air pressures between 80 and 110 lbs. per sq. in. or 65 and 90 lbs. per sq. in. as specified by purchaser. *R-7-o-1.

2. Air strainer of sufficient size, and so constructed as to insure an adequate supply of air free from foreign substance that may interfere with the operation of the valves or cylinder, shall be incorporated in mechanism or furnished by purchaser.

3. Pipe entrance shall be of ample size and conveniently located for external connection.

4. Each valve magnet shall be enclosed in a metallic shell.

(a) Terminal screws and washers shall conform to manufacturer's drawings.

(b) Material for terminal screws and washers shall be in accordance with Specifications for Various Types of Non-Ferrous Metals and Alloys, Manual Part 220.

(c) Threaded receptacles for terminal screws shall be mounted so they cannot be turned in the base or frame to which applied, properly insulated.

5. Magnets shall be designed for operation at 14 volts d-c.

6. Magnets shall operate satisfactorily when the voltage is reduced 20 per cent below rated voltage.

7. Rectifier, when specified, shall be furnished by manufacturer for mounting in the case.

8. *Binding Posts*

(a) Binding posts, nuts and washers for external connections shall conform to Drawing 1070. Soldered terminals or other suitable terminals may be used where no field wires are connected to such terminals.

(b) Binding posts shall be mounted so they cannot be turned in the base or frame to which applied. They shall be properly insulated from each other and other metallic parts.

(c) Binding posts shall be spaced not less than $\frac{7}{8}$ in. centers.

* Alternate requisites section.

9. Coil Insulation

(a) Coils shall be wound with insulated wire and treated so as not to be injuriously affected by atmospheric conditions or by changes in temperatures between 40 F below zero and 185 F above zero.

1. Wire shall be in accordance with Specification 193, Manual Part 183.

(b) Coils adjacent to moving parts, armature air gaps or contacts shall be treated by impregnation or dipping with insulating varnish in accordance with Requisites for Varnish Treatment of Electrical Windings, Manual Part 174. *R-9-b.

(c) Insulating material used for fillers in winding coils shall be chemically neutral.

(d) Coils shall be so insulated that they will withstand the insulation test provided in section 10. This test shall be made by mounting coil on a snugly fit metal mandrel and making breakdown tests between mandrel and winding; also by standing coil on each end in turn on a metal plate and testing between plate and winding.

10. Dielectric Requirements

(a) Electrical apparatus assembled shall withstand for one minute an insulation test, at place of manufacture, of 3000 volts a-c between all parts of electrical circuits and other metallic parts insulated therefrom. *R-10-a.

(b) A surface leakage distance of not less than $\frac{1}{4}$ in. shall be provided between any exposed metallic part of the apparatus carrying current and any other metallic part thereof.

(c) Separate windings, which are insulated from each other, shall withstand for one minute an insulation test of 3000 volts a-c between their terminals. *R-10-c.

11. Identification

(a) Mechanism shall be plainly marked with manufacturer's references.

12. Inspection

(a) The product furnished under this specification may be accepted upon manufacturer's certification that it is in accordance with the specification. If on arrival at destination the product is found not to meet the requirements of the specification it may be rejected and manufacturer, upon request, shall advise purchaser what disposition is to be made of the rejected product. Manufacturer shall pay all freight charges.

13. Tests

(a) Tests may be made at point of production, or on samples submitted, and may also be made at destination.

(b) Manufacturer shall give purchaser sufficient notice of time when the material or product will be ready for testing.

(c) Manufacturer shall provide, at point of production, apparatus and labor for making required tests under supervision of purchaser.

* Alternate requisites section.

13. *Tests—Continued*

(d) If tests are to be made at point of production, it shall be so stated on purchaser's order. Purchaser shall indicate which of the tests herein specified are to be made and what portion of the material or product shall be tested.

14. *Painting*

(a) Painting shall be in accordance with Instructions for Painting, Manual Part 110.

15. *Packing*

(a) Product shall be so assembled or packed as to permit convenient handling and to protect against loss or damage during shipment.

16. *Marking*

(a) Purchaser's order, requisition and package number, name of consignor, and name and address of consignee, shall be plainly marked on outside of packages and on tags attached to loose pieces.

(b) Detail list of loose pieces, packages and their contents shall be furnished for each shipment. Where carload shipments are made, routing and car identification shall be shown.

17. *Warranty*

(a) Manufacturer shall warrant the product covered by this specification to be free from defects in material and workmanship under ordinary use and service, his obligation under this warranty being limited to manufacturing, at point of production, any part or parts to replace those which shall be found defective within one year after shipment to purchaser. This warranty shall not apply to any product which shall have been repaired or altered in any way by anyone other than manufacturer thereof, so as to affect, in manufacturer's judgment, its proper functioning or reliability, or which has been subjected to misuse, negligence or accident.

Alternate Requisites

R-7-d.

Mechanism case shall be provided with cable entrance.

R-7-g.

Mechanism shall be designed to give at least $5\frac{1}{2}$ in. throw of the switch operating rod and shall give complete operation in seconds at volts or lbs. per sq. in. air pressure in bench test with no load on its operating rod, but not greater than 6 seconds.

R-7-i.

Means shall not be provided for manual operation.

R-7-j.

Means shall not be provided to disconnect power before manual operation.

R-7-k.

Mechanism shall not be designed to hold switch point in closed position when power is off.

Alternate Requisites—Continued

R-7-o-1.

Mechanism shall be designed to operate on air pressure between and lbs. per sq. in.

R-9-b.

Coils may be treated in other manner approved by purchaser.

R-10-a.

Electrical apparatus assembled shall withstand for one minute an insulation test, at place of manufacture, of 1500 volts a-c between all parts of electrical circuits and other metallic parts insulated therefrom, when approved by purchaser.

R-10-c.

Separate windings, which are insulated from each other, shall withstand for one minute an insulation test of 1500 volts a-c between their terminals, when approved by purchaser.

Exhibit 10-F

REPORT ON METHODS OF IMPROVING SHUNTING OF
TRACK CIRCUITS*

A questionnaire (Inquiry SS-131A) was issued to Voting Representatives of Member Roads in the former Signal Section having five or more votes. Replies were received from 37 railroads. The questions submitted and replies received are as follows; in many cases replies would list more than one condition or method—all reported are listed:

1. What conditions require efforts to improve track circuit shunting sensitivity.

(a) Yard Tracks

Railroads

- 3 —Poor ballast conditions
- 5 —Lightweight equipment
- 9 —Infrequent use of track
- 12 —Sand on rail head surface
- 15 —Oil and/or grease on rail head surface
- 20 —Dirt and other foreign material on rail head surface
- 23 —Rust on rail head surface

(b) Main Tracks

Railroads

- 2 —No difficulty experienced
- 2 —High speed movements with short equipment
- 3 —Use of equipment with off tread brakes
- 10 —Oil and/or grease on rail head surface
- 12 —Dirt and other foreign material on rail head surface
- 12 —Sand on rail head surface
- 14 —Lightweight equipment
- 14 —Infrequent use of track
- 16 —Rust on rail head surface

2. List and briefly describe methods used to improve track circuit shunting sensitivity by treatment of rail head surface.

(a) Yard Tracks

12 railroads reported none.

Cleaning rail head surface with:

Railroads

- 1 —Water sprinkler method
- 1 —Carbon tetrachloride
- 1 —Air jets

* Previous report on this subject appears in AAR Signal Section 1959 Proceedings, Vol. LVII, pp. 36-A and 181-A.

(a) Yard Tracks—Continued

Railroads

- 2 —Brushes
- 3 —Detergents
- 4 —Kerosene

Application on rail head surface of:

Railroads

- 3 —Oil to loosen rail film
- 3 —Copper strip
- 5 —Stainless steel strip
- 7 —Stainless steel beading
- 12 —Copper or bronze beading

(b) Main Tracks

Railroads

- 28 —None
- 1 —Scrapers attached to motor car to clean rail surface and using this device as often as felt necessary.
- 9 —Limited application of copper or stainless steel beading on rail head surface of turnouts and crossovers

3. List and briefly describe methods used to improve track circuit shunting sensitivity by treatment of track circuits, indicating special track circuits being used.

(a) Yard Tracks

Railroads

- 6 —None
- 1 —Slow pick-up track repeater relays where timing is not critical
- 1 —Relative high voltage d-c coded track circuits
- 1 —High voltage a-c d-c track circuits
- 2 —AFO type track circuits
- 5 —Style FR (ferro-resonant) Hi-Shunt type track circuits in classification yards
- 4 —Track relays having high release values
- 9 —Impulse type track circuits in classification yards
- 11 —Half-wave a-c d-c type track circuits
- 16 —High voltage d-c track circuits with limiting resistance in series at the battery and relay ends of the track circuit

(b) Main Tracks

Railroads

- 6 —None
- 1 —A-C full-wave rectified track circuits
- 1 —Coded energy for detection purpose only
- 1 —Time delay for track relay pick-up after shunt removed
- 2 —Primary-secondary track relay combination on all track circuits within interlocking limits
- 6 —Limited use of primary-secondary track relay combination

(b) Main Tracks—Continued

Railroads

- 3 —Track relays having high release current values and a normal release slow pick-up repeater relay to compensate for momentary loss of shunt
 - 3 —A-C d-c track circuits
 - 5 —D-C coded track circuits
 - 7 —Track relays having high release current values
 - 27 —High voltage d-c track circuits with limiting resistance in series at the battery and relay ends of the track circuit
4. List and briefly describe other methods used to improve track circuit shunting sensitivity.

(a) Yard Tracks

Railroads

- 29 —None
- 1 —Hand cleaning of oil and dirt from hump yard tracks
- 1 —The use of capacity in auxiliary circuit to open or shunt track circuit for a predetermined time interval after initial shunt is secured. This used in classification yards
- 2 —The use of a wheel detector to momentarily open track circuit when each wheel passes over the detector
- 1 —Cleaning of rail head surface with air jets or brushes
- 3 —Improvement of rail, ballast and drainage conditions

(b) Main Tracks

Railroads

- 27 —None
- 1 —Limited use of biased track circuits account rusty rail condition on branch lines
- 2 —Excitation circuits have been installed on Budd cars to improve shunting conditions and same have been found to be effective
- 3 —The use of wheel cleaning shoes on lightweight self-propelled equipment
- 4 —Improvement of rail, ballast and drainage conditions

The following additional information was received, under Remarks, from individual railroads:

"Our present plans calls for the conversion of all 0.6-volt primary battery to 1.3 volts to improve shunting sensitivity and operation."

"Hydraulically operated shunt brushes were installed on lightweight diesel passenger engines."

"Despite efforts to improve track circuit shunting by Budd RDC cars, we consider it necessary to maintain absolute block protection for following movements when single unit cars are operated."

"We have a few primary-secondary relay installations installed for experience; however, we have been able to secure satisfactory performance

by using the higher voltage cell with resistance at relay end and readjusting the track circuit."

"It is my belief that research would develop an economical arrangement to detect rapid fluctuations of track current supplied to the track as a result of intermittent shunting. In most instances moving equipment gives a partial shunt that fluctuates rapidly in value. This would be most useful as an adjunct to standard neutral track arrangements."

"There is no solution to improper sanding by track circuits modification. The problem of shunting efficiency is often confused with joint-hopping, these being two separate problems. This confusion has often resulted during operations of single unit self-propelled cars."

"The Budd Co. has developed a method of excitation for self-propelled diesel cars which is quite satisfactory."

"To take care of momentary loss of shunt and joint-hopping at crossing protections, a thermal relay is provided and directional stick relays made slow release. Shunting difficulties have also been experienced due to a combination of: weed spraying, branch line with infrequent rail traffic, and lightweight RDC units. I consider work should be done to investigate and correlate effects of these various factors with speed."

"When running single unit Budd cars on the main line the conventional track circuits cannot be depended upon for proper shunting. In this area we have installed a 'check-in'—'check-out' system in addition to our conventional track circuits. This system utilizes the existing train control inductors and additional check-in—check-out receivers on the Budd cars to open the signal control circuit when the car enters the track circuit. We also use the check-in—check-out system to reverse the polarity of biased neutral track circuits thereby de-energizing the track relays until the train leaves the section and restores the correct polarity."

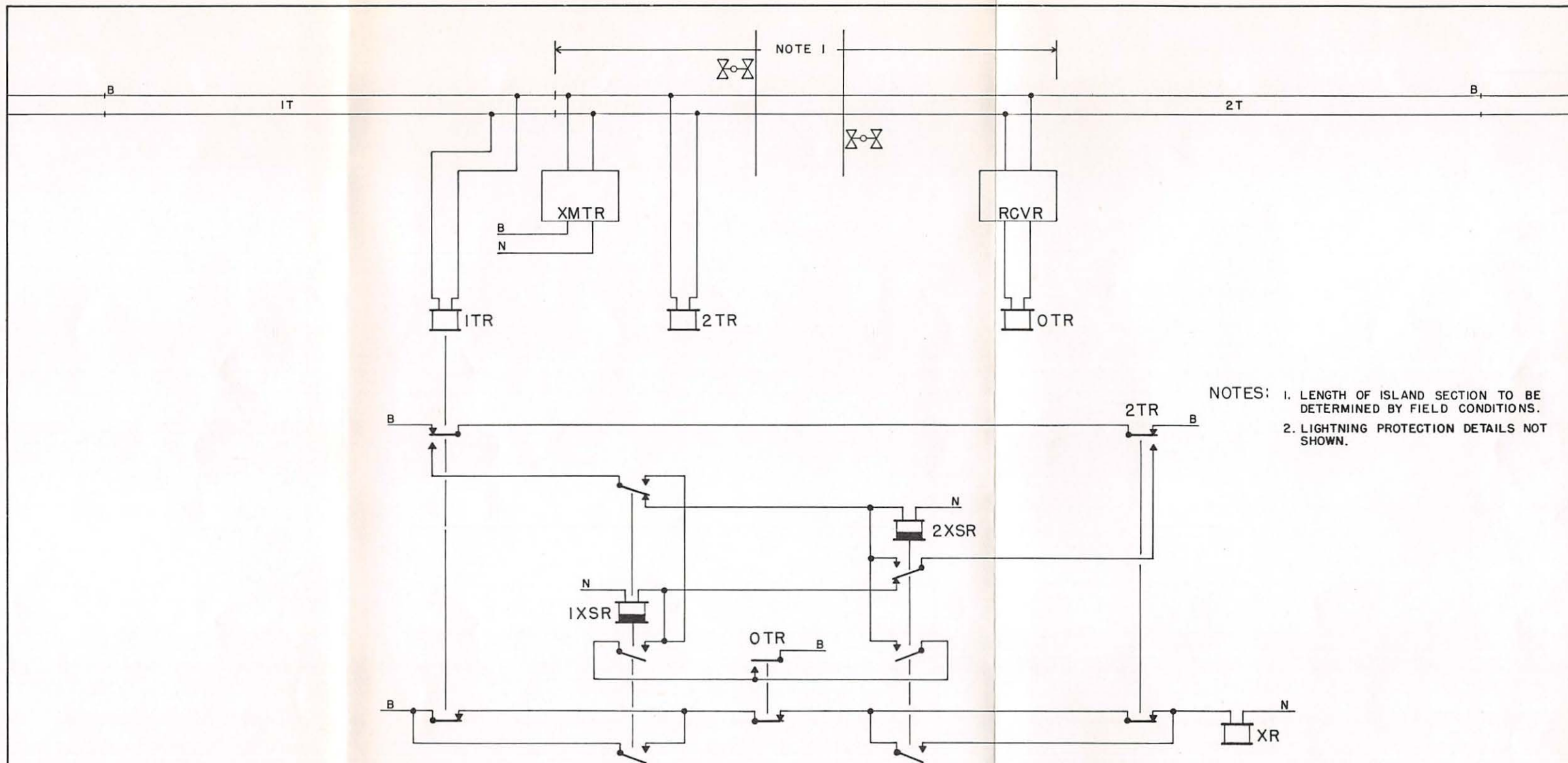
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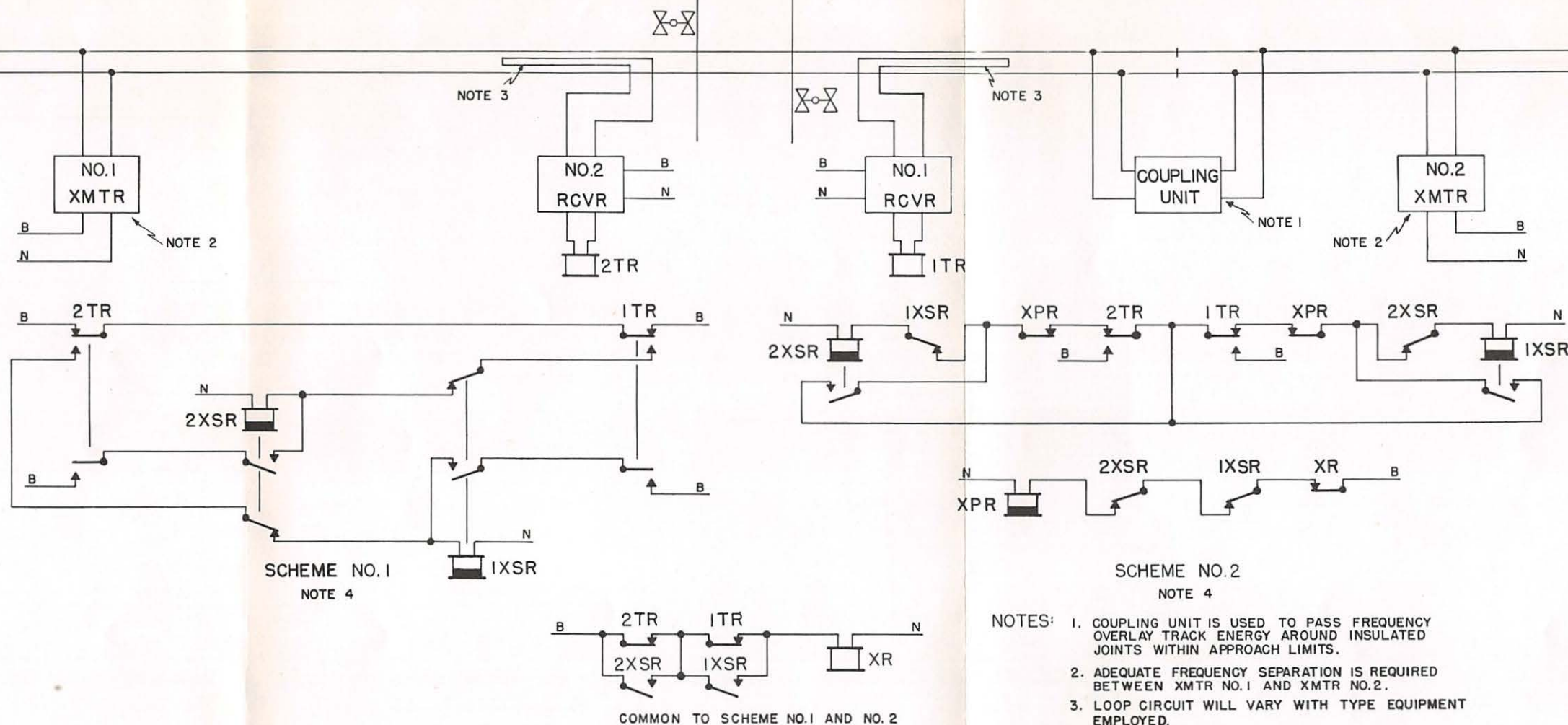
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TYPICAL CIRCUITS FOR AUTOMATIC HIGHWAY CROSSING PROTECTION

USING FREQUENCY OVERLAY TRACK CIRCUIT TO OBTAIN ISLAND CIRCUIT ON EXISTING HIGHWAY CROSSING INSTALLATION



TYPICAL CIRCUITS FOR AUTOMATIC HIGHWAY CROSSING PROTECTION

USING FREQUENCY OVERLAY TRACK CIRCUITS FOR APPROACH CONTROL